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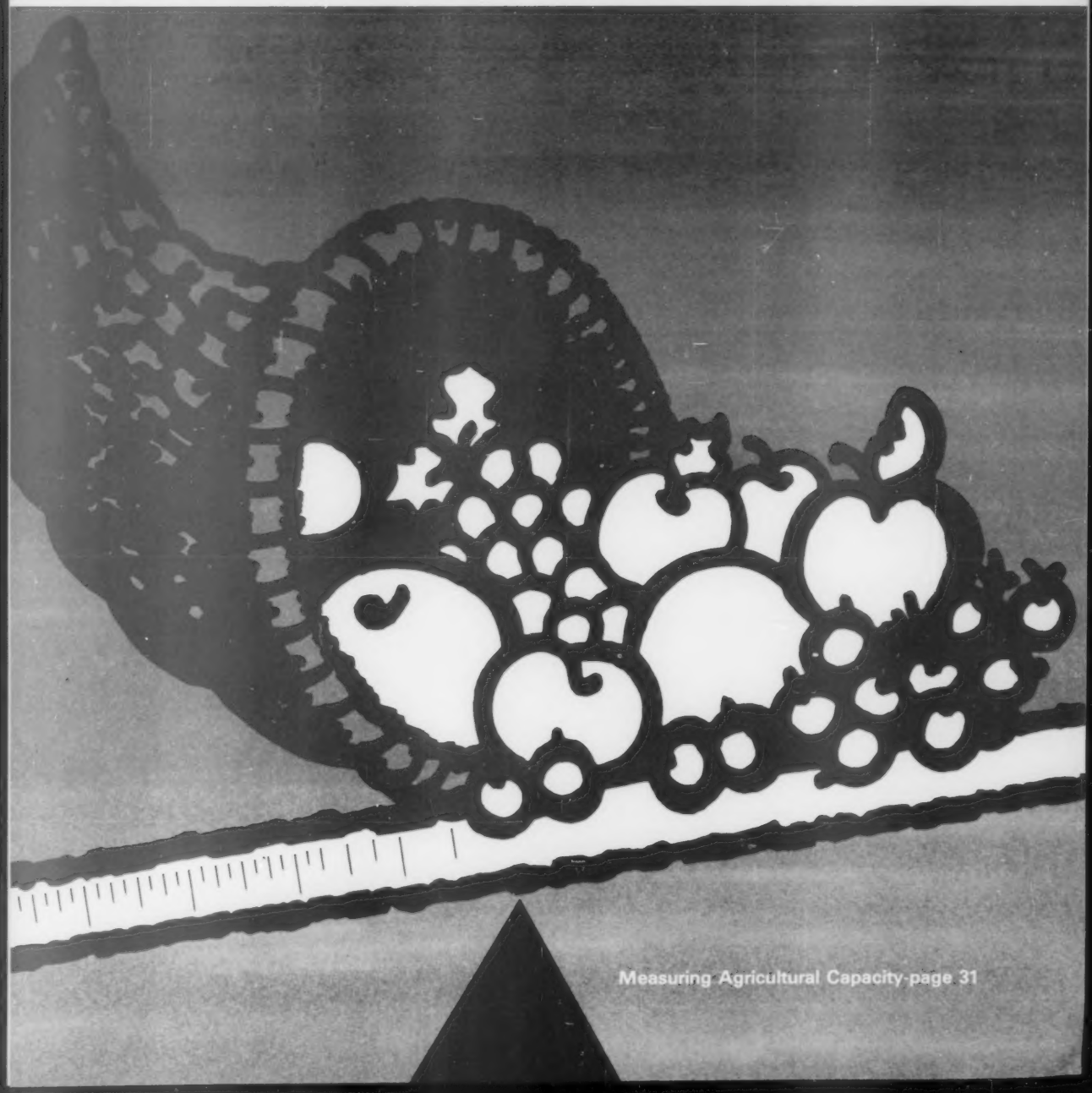

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CAPACITY MEASUREMENT IN THE U.S. AGRICULTURAL AND NONAGRICULTURAL SECTORS: A LITERATURE REVIEW

By Heinz Spielmann[1]

In an examination of the literature of agricultural economics from the fifties on, the author presents several definitions of production capacity of U.S. agriculture. No satisfactory measure of such capacity exists nor is there a viable, generally acceptable definition of the term. Literature of the nonagricultural sector contains some appropriate definitions and methodologies associated with capacity measurement. After discussing and evaluating several of these, the author suggests that some of them may provide help in making agricultural methods more useful.
Keywords: Agricultural production capacity, production capacity, capacity measures.

INTRODUCTION

A major problem confronting U.S. agriculture through most of the fifties and midsixties was the continued buildup of surpluses which proved costly to the Government and depressed market prices. Various policy attempts were made to mitigate this situation. Attempts on the demand side included the school lunch, food stamp, and P.L. 480 programs. On the supply side, producers were encouraged to abstain from continuing their high levels of production.

The agricultural economics literature of that time reflected a concern about excess capacity. Many long-range projections predicted continued surpluses on the supposition that the momentum of technological advance would keep food production well ahead of domestic population growth and of increasing per capita demand. The belief that the deficiency gap in the world's food budget would be closed by the eighties was reinforced by achievements of the Green Revolution. Pockets of starvation and near starvation were ascribed to faulty distribution, and the domestic quest for reduced production continued. Questions of precise measurement of agricultural capacity were not considered.

Following the surge in U.S. grain exports in 1972-73, it became clear that publicly imposed limits on production had worked only too well and that grain inventories had fallen dangerously low. Shortages occurred in fertilizer, energy, labor, and implements (particularly machinery). These shortages raised questions about the capacity of U.S. agriculture to produce food and fiber. In recognition of the international political impact of U.S. food production, and in view of domestic policies to make commodities increasingly reliant on the market rather than the U.S. Treasury, measuring agricultural capacity is assuming heightened importance.

A search of the literature for a suitable measure of agricultural capacity leads to the realization that no such measure seems to exist, nor is there a viable and generally acceptable definition of the term.

The literature of the nonagricultural sector, however, contains some appropriate definitions and methodologies associated with capacity measurement. Interest in this subject emerged about 1948. A number of more or less effective measurements have been developed, some of which are in use.

This article describes some of the efforts in both sectors to define and measure capacity and utilization. Methods for constructing capacity indexes are reviewed and their theoretical bases discussed.

Why measure capacity? It is important to determine the extent to which agricultural output can meet the serious food shortages throughout the world. Policy decisions depend on macroeconomic projections of capacity of agriculture, the conditions and policies required to use capacity optimally, and the efforts required to increase capacity. Microeconomic studies show that industry capacity utilization and operating costs are correlated, and that industry utilization rates are reliable indexes of capital expansion, early indicators of changes in profits, and pointers to hidden bottlenecks in the system.

DEFINITIONS OF PRODUCTION CAPACITY

The Agricultural Sector

The capacity of U.S. agriculture to produce is described in the literature in different ways. Brandow states that excess capacity exists when supply exceeds demand (*3*).[2] Converse conditions indicate undercapacity. Optimal capacity utilization is seen as equivalent to a market equilibrium wherein quantity supplied equals quantity demanded.

Quance and Tweeten define excess capacity as "... farm production in excess of market utilization at socially accepted prices" (*29*, p. 57). A measure of excess production is established by summing agricultural prod-

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[2] Italicized numbers in parentheses refer to items in References at the end of this article.

ucts held by the Commodity Credit Corporation (CCC) plus P.L. 480 shipments to foreign countries plus the potential from land withdrawn from production. Total capacity equals excess production plus commercial production. Excess capacity is the ratio of excess production to total capacity. The required conditions underlying attainment of capacity are not clearly established.

In a similar definition, Tyner and Tweeten view excess capacity as production (including potential production which could be derived from Government-directed land diversions) which exceeds commercial utilization. Excess capacity is calculated by dividing total production into the derived "excess" (*32*).

Culver and Chai made straight-line projections to the nineties of per capita demand for agricultural products, population, and gross national product (*6*). They also projected production, yield, and prices. Capacity is interpreted as the projected capability of agriculture to meet demand.

In an ERS article, capacity is the agricultural production projected for 1980 to 1985 under favorable prices and the assumption that all required inputs will be available (*34*).

Heady and Mayer define excess capacity as "cropland not needed to fill the demand" for agricultural products under various Government policy conditions (*17*). They predict that under conditions of no Government interference and free markets in 1980, considerable excess capacity in terms of available but unused acreage will exist, given the availability of all other inputs (*18*). In this definition, capacity is related to capital holdings.

In some of the literature, a definition of capacity can only be inferred, even when the title contains the words "excess capacity." One can infer from Ruttan and Sanders that excess capacity exists if agricultural production exceeds market demand (*30*). This definition resembles the concepts developed by Tweeten, Quance, and Tyner.

In a second study by Tyner and Tweeten, optimal resource use concepts are developed and excess capacity is defined as inefficient resource allocation (*33*). Many resources, particularly labor and land, have been overcommitted to agricultural production, which has resulted in low returns. Capacity means that level of production where optimal efficiency in resource use (least cost) is achieved at the same time that demand requirements are met. If one abstracts from the demand part of this definition, one comes very close to the concept of nonagricultural capacity described in the next section.

Several points stand out thus far:

1. Definitions of capacity vary considerably. Capacity usually is made dependent on both supply and demand. An excess capacity exists if more is produced than demanded in commercial markets. It may be inferred that capacity represents an equilibrium commercial market position wherein quantity demanded equals quantity supplied. Public storage, exports under P.L. 480, and potential production from land withheld all represent excess capacity. A few authors relate capacity to variable and fixed capital, and they align commercial demand with supply.

2. The assumptions underlying definitions of capacity also vary considerably. They range from normal conditions, wherein prices are socially acceptable, and continued technological improvements are expected, to substantial changes in public policy. An assumption of available fixed and variable inputs is explicit or implicit; limited inputs are not considered as limits to productive capacity.

3. Many authors did not define the concept of capacity explicitly, calling upon the reader to infer a definition from a series of "clues" in the text.

The Nonagricultural Sector

Capacity in the nonagricultural literature is frequently defined as the maximum output that can be produced with existing plant and equipment over a specified period of time. A profound definitional problem arises from the term "can be produced." There are two basic approaches: the so-called *engineering* approach and the *economic* approach. In most cases, both assume a normal operating intensity for the industry. For example, where operations use 3 shifts 24 hours a day, "normal" operations are around the clock. For other industries, an 8-hour day of operation is "normal."

The "engineering" approach specifies the maximum production from a plant using normal operations, without regard to cost or profit (*19*). Klein views the engineering approach as that output associated with fully utilized labor, capital, and other relevant factors of production (*21*).

In the "economic" approach, carefully established and precise underlying conditions are considered, including costs and optimizing objectives. It is here that divergences in capacity definition are most prominent.

The majority of investigators define capacity relative to shortrun, least-cost operations of the firm. Capacity in economic terms refers to a point where the U-shaped, shortrun, average cost curve is lowest. The difficulties with this approach are well known and numerous. First, it is uncertain whether cost curves can be established and whether the minimum of a cost/output ratio can be determined. Second, the U-shape of average cost curves may be only coincidental. Average cost curves of some firms appear to be flat-bottomed, others seem to show gradual decline, while others appear to reach a minimum very rapidly but only gradually rise thereafter (*7*; *26*).

With divergent cost conditions in mind, DeLeeuw suggests that capacity should be measured along the marginal cost function at a "level of output at which shortrun marginal costs are (x) percent above minimum shortrun average costs" (*9*). This criterion would imply that the cost of an additional unit of output would incur sharply higher unit costs than would the cost of the most efficient output. The value of x would be uniform

throughout each industry and it would be estimated empirically.

Another interpretation of capacity is related to the capital stock held by an individual firm. Given a constant stock of capital, an output may be reached wherein the acquisition of additional capital stock may be advisable (*26*, p. 95). At this point, which will likely occur before the minimum average cost is reached, lower operational costs can be achieved by appropriate changes in plant and equipment. This concept defines capacity as an economic limit to the rate of output of existing fixed capital.

This review discloses a variety of definitions of nonagricultural capacity. It will be shown later that these lead to divergent methods of numerical estimation. Most of these methods start from the firm level and aggregate to weighted industry indexes. Relatively close agreement exists on numerical estimates of capacity. Conceptually, there are several points of apparent concurrence:

1. Continued availability of fixed and variable inputs.
2. No changes in technology or in the *modus operandi* of individual firms or in their product mix.
3. The quantity of capital stock, plant, and equipment is held constant for the relevant output.
4. Capacity as a cost concept is defined to occur at minimum average cost for the firm.
5. Capacity is independent of demand.
6. The concept of capacity is viewed at the firm level.

No clear cut definition of capacity was found in either the agriculturai or nonagricultural literature. However, the statement that "capacity is that output which can be produced at minimum average total cost, given existing stock of plant and equipment and existing techniques and factor prices" appears to capture the general consensus in the nonagricultural literature.

CAPACITY MEASUREMENT METHODOLOGY AND EVALUATIONS

The Agricultural Sector

The empirical methods employed to derive measures of agricultural capacity are not discussed by some of the authors reviewed. Others base capacity measures on simple straight-line projections of production, land use, and labor data. Others provide complete descriptions of the methodology employed.

Heady (*16*) estimates U.S. production of 7 major crops in 144 producing and 31 consuming regions. A linear program establishes optimal production levels and transportation flows for each crop in each region. Projections of yield and expected consumption are made for 1980. The outcome is a regional pattern of least-cost production with flows for consumption in those regions which have lower relative advantage. This system incorporates estimated and well-defined demand parameters, and considers Government policy conditions ranging from free markets to acreage restrictions.

Tyner and Tweeten use a simulation model to test the ability of the agricultural sector to divest itself of its "excess" capacity and to return to "normal" capacity operation (*33*). The model uses recursive aggregate supply and demand equations. One can infer optimal policies to induce operation at "capacity." While the authors speak of agriculture's ability to remain viable, they use their model to simulate attainment of capacity output through Government programs.

Some writers, although they do not define capacity, couch their capacity predictions in a variety of scenarios. Brandow speaks of standard and high demand situations, thus making capacity a function of demand (*3*).

Future conditions assumed in an ERS article center around four points (*34*):

1. Farm product prices favorable for increased production,
2. No restrictions in land use,
3. Adequate input supplies, and
4. Normal growing conditions.

Quance and Tweeten show presence or absence of excess capacity under various Government policy conditions, differing demand and supply elasticities, and varying supply and demand shifts (*29*).

Heady and Mayer assume that demand will continue to increase proportionally with population and income (*17*). They assume the rate of increase in productivity will be that which prevailed in 1950-65 and export demand will continue at 1965's levels. These assumptions imply continued excess agricultural capacity and, therefore, reduced cropland acreage requirements.

Many of the writers take an "engineering" approach to agricultural capacity assessment by adding all possible available land and inputs and comparing these with demand estimates. Authors who use a more "economic" approach tend to more pessimistic outcomes.

Highly diverse methods of agricultural capacity determination are employed by various investigators. However, the empirical methods are not always consistent with the concepts of "capacity" as previously defined. In addition, there is a considerable lack of data on which to base capacity estimates. As a consequence, estimates of agriculture's current and future capabilities differ widely.

The Nonagricultural Sector

A number of private and Government economists have, in addition to attempting a clear, uniform definition of capacity, addressed themselves to various methods of capacity measurement. Four such capacity measures will be reviewed and evaluated:

- McGraw-Hill measures of capacity and industrial rates.
- Manufacturing Capacity Index of the Bureau of Economic Analysis, U.S. Department of Commerce.
- Wharton School Index of Capacity Utilization.

- Federal Reserve Board Capacity Utilization Index for Manufacturing and Major Materials.

I shall also touch on a system used by the Industrial Conference Board and briefly discuss two additional theoretical approaches.

Some of these indexes and systems date back to 1948; others are of quite recent origin. Methodologies vary considerably. The outcomes of measurements, however, are much closer to each other than was found in the agricultural sector. Among the reasons may be these: the various agencies involved in capacity measurement seem to use the same basic data; there are fewer industrial firms functioning under less complex and diversified conditions than in the agricultural sector; and entrepreneurs in the nonagricultural sector have greater control of productive processes and input decisions than those in the agricultural sector.

Two basic systems are used. In one system, persons directly interview individual members of firm management to obtain data on capacity, capacity utilization rates, and desired (preferred) capacity utilization. In the other system, secondary data from various Government agencies are used. Sometimes both systems are used. Before describing these methods and systems, two additional definitions are presented.

Capacity utilization rate (operating rate) is the ratio of output of the firm to capacity at a given instant in time. If *engineering* capacity is the denominator, and if such capacity means total physical use of all fixed factors, the capacity utilization rate can never exceed 100 percent. If, however, *economic* capacity is the denominator, capacity utilization may exceed 100 percent; it would be possible for a firm to operate on the upswing of the average cost curve and not have exhausted physical capacity.

Desired capacity utilization rate is the operating rate of a firm which corresponds to management's policy framework concerning profit, the satisfaction of various members of the coalition comprising the firm, and other considerations.

The McGraw-Hill Measurement of Manufacturing Capacity Utilization. McGraw-Hill relies heavily on direct survey data. A number of business firms, representing about 63 percent of total fixed assets of all business firms (1974) and located in 20 industries, are surveyed annually. These firms are not randomly chosen; they encompass the largest firms with well-advised management willing to respond to the mail questionnaire.

Two major indexes are constructed by McGraw-Hill—one, of changes in capacity utilization rates and the other, of changes in capacity of firms, industries, and the total manufacturing sector. Two distinct sets of capacity utilization data are generated from the surveys (*12*). One covers annual changes as of December of each year; the other measures monthly changes.

The annual survey is conducted in the spring. McGraw-Hill requests three types of data:

- Information on the percentage of output relative to the firm's capacity during the previous year. (Economic capacity is implied.)
- Desired (preferred) capacity utilization.
- Information on capacity changes based on net changes in capital stock.

Information from the firms is aggregated into industry data through use of employment weights. Analysts use value-added weights derived from the 1967 Federal Reserve Board Index of Industrial Production (IP) to combine the 20 industries into major industry groups, such as durable and nondurable goods, and into total output.

For estimates of monthly capacity utilization, McGraw-Hill uses the spring survey responses on expected changes in net capacity. These changes are prorated over the survey year on an equal 12-month basis. Again, responses by firms are combined into industry groups. Net changes in monthly capacity from the McGraw-Hill Survey are divided into the monthly production changes in the IP. The result is a monthly capacity utilization rate (operating rate) by industry. Value-added weights are applied to each industry (as in the annual survey) to estimate the total capacity utilization rate. The December operating rate serves as a benchmark for the following year's monthly operating rates.

Various revisions are made in the index derived by McGraw-Hill, to align expected capacity changes with subsequent estimates of actual capacity changes throughout the year. Revisions are also required when the IP is revised.

McGraw-Hill also develops an index of the effective operating rate. This is the ratio of the index of actual to the index of preferred operating rates.

The terms capacity, operating rate, and desired (preferred) utilization rate are never defined in McGraw-Hill questionnaires. Responses have been sharply reduced when terms are carefully defined. Strangely enough, responses to undefined terms have corresponded very well to what McGraw-Hill means by these terms. Management appears to know intuitively the meaning of capacity, operating rates, and desired (preferred) capacity rates. Respondents generally appear to apply the concept of optimal (profit maximizing) performance in their response on preferred operating rates.

The McGraw-Hill series has a number of drawbacks. The indexes are not analytic. They report *ex post facto* conditions, although they can be used to predict capacity growth. They depend on opinions and estimates by the management of a limited number of large firms, although these are well-educated guesses based on years of experience. And, McGraw-Hill does not clearly define capacity. As Gift states, "... They work under the conviction that a large response to a vague question is more useful than a small response to a precise question, especially since the sample is not done randomly from a preestimated frame ..." (*13*, p. 32).

A strength of the McGraw-Hill series is the availability

of capital expenditure intentions. Also, the series data reflect the view managers have of their firms' capacity and operating rates, which may give insight into industry behavior.

The Bureau of Economic Analysis Index. The index prepared by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, covers manufacturing firms primarily. The Bureau surveys a panel of 2,400 manufacturing firms. The survey represents 75 percent of gross depreciable assets held by all manufacturers as of 1969 (*19*). Firms are asked to give capacity utilization and the desired (preferred) operating rate.

Here, the similarity between the BEA and McGraw-Hill systems ends. The BEA Survey has been quarterly since 1968. It categorizes firms into durable and nondurable goods manufacturers. It places them into three asset size classes: $100.0 million or more; $10.0 million to $99.9 million; and less than $10 million. The survey is part of a continuing BEA program which provides series on actual and expected plant and equipment expenditures, carryovers, and new investments.

Estimates of capacity utilization rates depend on calculations in which company capacity outputs are used as weights for combining firms into industry groups. Three steps are followed: First, individual company capacity utilization rates are combined to estimate rates by the 25 industries and by the 3 asset size classes; second, utilization rates of the 3 asset size classes are combined to obtain industry rates; third, industy rates are combined to obtain rates of industry groups.

The BEA indexes provide researchers with historical capacity utilization rates in manufacturing firms. For example, utilization rates were higher before 1969 than after. The indexes describe the peaks and troughs of utilization rates, and they identify groups of industries that had higher or lower levels of capacity utilization than other industries did. The indexes are a source of estimates of the correlation between size of firm and capacity utilization; larger firms had consistently higher utilization rates than medium-sized and smaller firms.

The BEA system allows tracing of total capacity development and it indicates the relationship between growth and capacity. Industries with lower than average utilization rates showed lower than average capacity increases over time. There have been, however, some notable exceptions to this rule, and no causality was established. The indexes demonstrate that preferred (desired) operating rates have been considerably higher than the actual rates. Thus, the effective utilization rate (ratio of actual to preferred capacity utilization rates) has been relatively small. These rates foreshadow desires by firms or industries to increase or decrease their assets. A high effective operating rate indicates that firms do not want added investment in new equipment, that output will not be raised until (or unless) product prices become more favorable. BEA investigators have discerned that the extent to which high operating rates induce plant expansion differs among industries and industry groups.

The Wharton School Index. The Wharton School system does not involve a survey. Its conclusions are entirely inferential. It is based on the contention that capacity is

> . . . the maximum sustainable level of output the industry can attain within a very short time if the demand for its product were not a constraining factor when the industry is operating its existing stock of capital at its customary level of intensity (*25*, p. 2).

This is an engineering definition of capacity, conditional on customary operations and independent of demand. It is measured in the short run (no fixed factor changes), and it lacks economic indicators (such as cost, profit, investment rate, and so on).

Monthly outputs from the Federal Reserve Board (FRB) index for each industry are combined by quarter. They are plotted on large graphs, and peak quarters are connected linearly. Formation of a peak quarter, when production in the preceding and following quarters is lower, is interpreted to imply achievement of a maximum sustainable output with existing equipment. A 100-percent capacity level is ascribed to each peak. The line connecting peaks denotes "full capacity." Extended like a trend line past the last peak, this line is continually adjusted with new data. The distance between the capacity trend line and the points representing actual production measures unused capacity.

This approach is a rather easy approximation of capacity utilization. However, it is more useful for historical than current measures. Continued adjustment of the capacity line may cause a low current estimate of capacity utilization to be readjusted to a high level in some subsequent quarter. An historical view may provide a quite different result than current measurements. There are some questions as to whether a straight-line interpolation is better than a curvilinear function. Adams and Summers contend that other factors, such as increasing nonproductive investments, distort the picture sufficiently to make a straight-line interpolation as applicable as any (*1*).

The Wharton Index consisted at first of 30 components of the FRB Industrial Production Index, representing manufacturing, mining, and utilities. More recently, six service industries were included (rails, airlines, trucking, residential housing, offices, and hotels).

To obtain capacity utilization in the whole industrial sector, a weighting system is applied to each industry, one that involves the estimated proportionate contribution of each industry to total national income at full employment. These proportions are estimated for quarters when the economy was operating close to full employment and they are interpolated linearly for quarters in between.

The Wharton Capacity Index has strongly deviated,

particularly since 1966, from the other capacity indexes, and it shows significantly higher capacity utilization rates (*27*). As a rough approximation used in conjunction with other data, the Wharton Index has merits. However, it appears subject to considerable errors in the long run. Some alternative systems suggested by Klein are designed to be more analytic, but they also have some serious drawbacks (*20*).

The Federal Reserve Board Index of Capacity Utilization. There are two basic parts to the FRB Index of Capacity Utilization. One involves 15 materials industries (iron, steel, lumber, and so on); the other, primarily manufacturing. For materials industries, December production data are collected from industry sources. Where available, year-end data on physical capacity of the engineering type, are collected from the Government and from trade associations. These data are used to estimate physical quantity of potential output (operations largely on a 24-hour basis with adjustment for downtime, repairs, and other short term stoppages). The ratio of actual December production to December capacity yields the preliminary utilization rates. Data are weighted by value-added figures for combination into industry groups. The ratio of the Federal Reserve Industrial Production Index for December to the preliminary utilization index is then calculated. The result, the capacity index, is interpolated linearly into a quarterly index. The ratio of the quarterly FRB Industry Production Index to the quarterly capacity index yields the seasonally adjusted quarterly materials capacity utilization index.

This relatively simple measure largely treats trade information directly. However, capacity information is extremely scarce and difficult to obtain. The measure is incomplete, although it does touch on the major materials (basic processed products) of the economy.

The second FRB index reviewed is concerned primarily with manufacturing. It is based on the concept that biases in one index can be mitigated by biases in another. The manufacturing index uses: (1) estimates of fixed capital stock made by the BEA, U.S. Department of Commerce, (2) the McGraw-Hill manufacturing capacity index, and (3) the ratio of the FRB Industrial Production Index to the McGraw-Hill capacity utilization index. This ratio is designated as the derived capacity.

It is assumed that the BEA and McGraw-Hill manufacturing indexes tend to drift away from the desired measurement because of differences in weighting methods, sample biases, varied assessments of capital stock size, and changes in rates of obsolescence and depreciation. A set of time series with the adjusted derived capacity as the dependent variable is used to correct for this drift.

The two capacity measures of the Federal Reserve Board are rather crude and, because they lack sufficient information, incomplete. Yet De Leeuw was able to derive from them a number of interesting characteristics. He determined a correlation between relative material prices and capacity utilization (*8*, p. 126). He found that, after a 90-percent capacity utilization rate was reached, a sharply increasing positive relationship with materials prices prevailed. Materials prices were deflated by final product prices. He showed that capacity utilization cycles preceded investment cycles by 1 year. De Leeuw concluded that "we have good reason for supposing that capacity influences prices, costs, and fixed investment . . ." (*8*, p. 131).

National Industrial Conference Board Capacity Measurement

The method of the National Industrial Conference Board incorporates the relationship of the capital stock of a firm to capacity utilization. It is based largely on the definition of capacity given by A. Phillips (*28*). A range of outputs in an industry can be produced with given capital; no capital is added due to output variation within this range. At a certain level of output, however, there will be a tendency to purchase more capital goods. It is this level which Phillips considers the capacity of the industry.

The Conference Board develops a ratio of available fixed capital (in constant dollars) to industry output at a cyclical peak, when it is assumed that full capacity has been attained. This point becomes a benchmark. A subsequent increase in the fixed capital-output ratio relative to the benchmark year indicates excess capacity. Conversely, overutilization would be indicated by a ratio lower than the benchmark.

A problem with this method arises in the measurement of fixed capital. The Conference Board index relies on balance sheet data to obtain estimates of net capital stock. These data may be biased by inflationary impact, inadequate depreciation rates, inventory valuations, or technological differences which cannot be expressed in monetary terms (for example, a new piece of equipment costing 50 percent more than the one it replaces may be 100 percent more efficient).

The above discussion summarizes the prominent capacity and capacity utilization measurements in the nonagricultural sector. Other measurements, which are based on highly theoretical assumptions and have found little practical use, are discussed briefly in the next section.

OTHER METHODS OF DETERMINING CAPACITY AND CAPACITY UTILIZATION

There are other methods one can use to determine capacity and capacity utilization, methods based on hypotheses not yet discussed. Two such methods appear below; they remain experimental and have not been used to construct continuing indexes.

An interesting system which promises eventual implementation is that developed by Hickman (*20*). It assumes that real net investment by a firm is proportional to the difference between actual and desired capital stock levels.

Capacity levels are inferred from investment behavior, or capital stock changes, of firms.

Real net investment is the change in real net capital stock over time. The desired capital stock is what would exist in a longrun equilibrium wherein the ratio of marginal physical product of capital to the price of capital equals the ratio of the marginal physical product of any other input to the price of that input.

Hickman postulates that capacity is a cost concept; it depends on capital stock, technique, and resource prices. He defines capacity as being at that point where the average cost curve is lowest. At this output, the existing capital stock is equivalent to the desired stock. Any increase in production will elicit a proportional increase in capital stock. Similarly, changes in production costs, as well as in technology, will directly affect capital stock. Given the existing capital stock, the real price of capital, and existing technology, optimal (capacity) output may be determined. Capacity is a function of relative prices and time. Hickman claims this method requires neither a production nor a cost function for capacity measurement.

The concept that net investment is proportional to the excess of actual over desired capital stock has been exchanged with the concept that net investment is proportional to the excess of "normal" over optimal (capacity) output. Since capacity is set at the point of minimum average cost, the derived economic utilization rates may exceed 100 percent. This method allows projections of capacity growth associated with different rates of capital formation. It requires a regression equation wherein net investment is the dependent variable, and output and relative prices, the independent variables. Data are required covering capital stock, output, product prices, capital goods prices, interest, depreciation rates, and wage rates. Capacity output is applied to "normal" output (the weighted average of current and recent outputs) to obtain the "normal" utilization rates of an industry.

Hickman compared his results with those obtained from other systems, some of which were reviewed above. He found that those systems using capital levels and changes as main components fit more closely to his than did the others. There are no great differences in changes of capacity between his and most of the other indexes. His capacity utilization measures exceed 100, in most cases, while the others do not. His deviations from both the McGraw-Hill and Wharton indexes appear to be quite large.

Information on the desired (equilibrium) capital stock would be quite difficult to obtain. Aggregation problems associated with Hickman's system would be complex. However, improved research on the relationship of capital stock changes to output may well lead to greater applicability of his method.

Klein and Preston use the production function approach in capacity utilization measurement (*24*). They start with a Cobb-Douglas production function whose main elements are: (1) currently employed labor, (2) currently utilized capital, and (3) technological change. Full capacity output is defined as a function of full employment of labor and capital. To satisfy the least-cost equilibrium condition, the rate of marginal substitution of capital for labor is equated to the ratio of capital returns to wage rates. To derive capacity output, the substitution rate is introduced as a coefficient to current capital in a regression analysis. The dependent variable is output and the second independent variable is current labor use. Thus, suitable adjustment of the capital stock determines capacity. Capacity utilization rates are established by the ratio of the observed output to computed output.

Some of the major problems are associated with the complexity of determining the size of currently utilized capital stock and currently employed labor. These difficulties would be particularly aggravating in the agricultural sector. Problems arise with the valuation of wages and returns to investment. Not only public policy but also the mixing of labor and entrepreneurial income in the agricultural data cause serious empirical problems. Nevertheless, the Klein-Preston method is promising.

COMPARATIVE EVALUATION OF EXISTING CAPACITY MEASURES

Capacity measurements in the agricultural sector are not based on a clearly defined concept. They represent longrun market equilibrium positions. They reflect highly divergent assumptions. They have diverse outcomes. A more careful definition and more consistent assumptions will be required to construct a reliable index of agricultural capacity.

Capacity measurements in the nonagricultural sector are based on more consistent assumptions and a clearer definition. They show less divergence than in the agricultural sector. However, George Perry finds that nonagricultural capacity estimates have shown increasing disagreement since 1966 (*27*, pp. 718-21). The following table shows Perry's pertinent capacity utilization data for four indexes for 1966 and 1969:

Comparative capacity utilization rate indexes, nonagricultural sector, 1966 and 1969

Index	1966	1969
Wharton School	96.1	96.2
McGraw-Hill capacity utilization	90.0	85.8
McGraw-Hill capacity	91.5	87.3
Federal Reserve Board capacity utilization	92.3	87.1

Source: (*27*, p. 715).

These divergences are partly caused by capital acquisition induced by accelerated wage increases and increased foreign competition. The capacity measurement methods cannot readily cope with such exigencies.

To determine the ability of three of the indexes (McGraw-Hill capacity index, McGraw-Hill capacity utili-

zation index, and Wharton index) to predict changes in three factors—capacity, real investment levels, and prices—Perry developed regression equations (*27*, pp. 723-33). The three factors were dependent variables and the three indexes were included among the independent variables. Both McGraw-Hill indexes did quite well in predicting growth in capacity; the Wharton index did not. All three indexes proved usable for predicting levels of investment, but the Wharton index gave the weakest results. All three indexes predicted prices quite well.

Biases in the capacity utilization rate index due to capital obsolescence, changes in capital-labor ratios, and changes in technology are avoided when responses by experts in management, as in the McGraw-Hill survey, take such changes into account.

Perry found the following:

- The FRB capacity index seems to have drifted away from its early benchmark and it has shown some considerable errors (10 percent in 1973).
- The other three indexes studied can help to describe the effects that capacity utilization rates have on investment and price levels. They are less useful in predicting capacity utilization rates (except for the McGraw-Hill capacity utilization index).
- The Wharton index cannot distinguish utilization intensities at peaks in the Federal Reserve Board Index of Industrial Production. Problems with the Wharton index are associated with the frequent adjustments as new data are generated.
- In the test of the most price-sensitive industries, the McGraw-Hill capacity utilization index appears to give better indications than the Wharton index. The McGraw-Hill index shows that operating rates were considerably lower in the 1973 quarters than in the 1966 quarters, but close to the 1969 quarters when inflationary pressures began, the Wharton index shows little difference.
- The McGraw-Hill capacity utilization index appears to be the most useful of the four indexes examined.

CONCLUSIONS

A review of the literature on capacity measurement in the agricultural sector shows considerable diversity in analysis and predictions. These divergencies are partly due to an insufficiently cohesive definition of the term capacity and to the plethora of assumptions. An additional reason appears to be the lack of the "right" kind of information. Brandow states.

> Anyone seeking to make estimates of how much the U.S. could increase its agricultural production under strong incentives for more output will be impressed by how little solid information is available on the subject . . . (*3*, p. 1100).

He further submits:

> . . . we do not know much about the economic barriers to cropping all the land considered available according to soil conservation criteria, nor do we know clearly the net addition to output to be realized by cropping the land . . . .

It is clear that an information base suitable for capacity measurement should be developed.

For the nonagricultural sector, while definitions of the terms and methods employed in measurements are also divergent, there is more agreement on a definition. In addition, data from both primary and secondary sources have been developed on which to base continuing indexes. Despite the divergence that exists in definitions and methods, values of capacity indexes in the nonagricultural sector are—with one exception—not very far apart from one another. Even so, they remain quite crude and research is needed to sharpen them up and improve their reliability.

Capacity measurements are strategic in several indexes (FRB wholesale price index) and econometric models (Wharton School), and they are used in many ways. Their increased use will require more information than is currently available. This question is discussed at length by Spielmann and Weeks (*31*), and it is briefly reviewed here.

Capital utilization in the agricultural sector has different characteristics than in the nonagricultural sector. Industrial capital equipment is normally quite specific to the industry. The manufacture of glass, for example, requires equipment exclusively suited to that purpose. Consequently, capacity as well as capacity utilization rates in the glass industry, can be readily gauged by net changes in glass manufacturing equipment.

In the agricultural sector, farm equipment is far less commodity specific. The same may be said for land and labor. Factors such as weather and disease, which have no relevance to capacity output in the nonagricultural sector, have very important and frequently uncontrollable impacts on capacity in agriculture. The complexity and variability in agricultural conditions lead to the conclusion that current econometric and statistical tools cannot help us obtain reliable capacity determination until much more, better information becomes available.

The survey methods employed by McGraw-Hill and the Bureau of Economic Analysis come closest to meeting agriculture's needs. Accuracy would be improved as information is gathered, and as both interviewers and farm managers refine questions and responses. Considerable time, experience, and effort will be required to develop a workable and useful series on agricultural capacity. Whether one of the systems reviewed above can be employed for a capacity and capacity utilization index in the agricultural sector depends on its adaptability to the special characteristics underlying agricultural economic activity.

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IN EARLIER ISSUES

Strip coal mining is a rapidly expanding industry competing with agriculture for the use of lands that are underlain by suitable coal deposits. . . . As the industry grew and its operations removed ever-increasing areas from agricultural uses, the conflicts in the interests of the strip-coal companies and the local people became increasingly evident. . . . Lack of sufficient information and understanding about the variety of conditions under which strip coal mining is done is partially responsible for the diversity of the proposals for legislative regulation. . . .

Strip coal mining is an extractive industry which will probably continue as long as suitable coal deposits exist. It is increasingly recognized by both companies and citizens that the industry has an obligation, however, to help so far as possible to minimize the effects of its operations on the people in the communities in which it operates. It is of importance not only to the local people and the coal companies but to the general public as well that the stripped lands be returned to an economically sound and productive use after mining operations cease. Society has the ability through legislation to protect the interests of any individuals or the public as a whole if future research discloses such need.

George H. Walter
Volume 1, Number 1, pp. 24, 29
January 1949

There is a . . . question . . . as to where and how workers in the Bureau will find time to write articles. However, in many instances there is need for at least a progress report well before a study is wholly completed. We believe that there is good reason why a considerable amount of such work should be published in a permanent journal rather than in mimeographed form, especially as mimeographed releases are always difficult to find once immediate interest in the subject has subsided. As a matter of fact, there are several excellent reasons why researchers and statisticians within the Bureau generally should give more rather than less time to bringing their material into some organized written form. After all, *agricultural economics work is carried on in the public interest and every researcher or statistician, regardless of his field, does have a responsibility for seeing that his material is prepared in such a way as to be readily accessible to his fellow workers and to the public.*

O. V. Wells
Volume I, Number 1, p. 2
January 1949

REDUCING RESPONDENT BURDEN FOR REPEATED SAMPLES

By Robert D. Tortora[1]

Repeated sampling from a frame to make estimates in different subject matter areas may increase the burden on survey respondents. Two methods for determining selection probabilities are presented that reduce the burden. The first method takes into account the previous number of contacts of a sampling unit; the second, the length of interview on previous contacts.
Keywords: Respondent burden, sampling theory, selection probabilities.

INTRODUCTION

Reducing respondent burden must be a goal of any agency that repeatedly contacts the public to obtain data. This goal has been emphasized by the Office of Management and Budget (OMB) (*2*).[2] OMB is particularly concerned with reducing the burden on private citizen respondents that are associated with data collection by the Federal Government. The Statistical Reporting Service (SRS) wants to reduce the burden on persons contacted repeatedly for voluntary responses to USDA surveys. More SRS survey work is being placed on a probability basis, and new methods should be presented to reduce the burden while retaining the probability characteristic of the surveys.

The principal factors that make up the burden placed on a particular respondent participating in surveys are: (1) the time it takes to complete an interview; and (2) the number of contacts during some time period, for example, a calendar year.

The burden on particular respondents is sometimes reduced by excluding from the next survey sample all persons surveyed previously. However, this practice violates the concept that each sampling unit must have a known positive probability of selection. Total respondent burden can be reduced by curtailing sample sizes, thus reducing the number of contacts made. However, this approach provides no relief for the respondents included in a smaller sample, and it may reduce precision (that is, increase the variance) to an unacceptable level.

I will address the two factors listed above for the case when the same frame L is used to select samples for K surveys covering different subject matter areas during some time period. Separate procedures for each factor will be suggested. Both procedures reduce respondent burden by increasing the probability of selection of sampling units not contacted previously, while decreasing the probability for those contacted previously.

In agricultural surveys, sampling frequently is done using lists of farm operators. For example, in each State, SRS is developing one list of farm operators for surveys. Each list contains the operator's name and address, and information about the types and numbers of livestock species, poultry, and crop acreage. Procedures should be instituted to reduce the burden placed on individual operators on this list.

Now let us assume that where the selection probabilities are altered to reduce respondent burden, the surveys are *ad hoc*; and no rotation of sampling units occurs. Further, the surveys are large enough so that estimators based on probability proportional to size (pps) without replacement sampling show only small gains over pps sampling with replacement. That is, we assume the proportion of the sample size to the population size (nN^{-1}) is small. In the method, we use the concept of replacement sampling. We can then account for the previous individual burden on a farm operator by adjusting selection probabilities.

SELECTION PROBABILITIES FOR NUMBER OF CONTACTS

When samples are drawn from a frame to estimate different subject matter areas, and the data collection does not involve lengthy interviews, the number of contacts represents the most important factor contributing to respondent burden.

Proposed Method

Suppose that the frame L is used to select K samples of size n_i, $i = 1, \ldots, K$ for K different subject matter surveys. Further, suppose that the first several surveys (P of them) have been conducted.

Let γ_j, $j = 0, 1, \ldots, M$ be the number of sampling units selected j times in the first P surveys. Note that M can be greater than P because we assume with replacement sampling. For the P+1st sample to be selected, we want to associate with each member of the frame a probability that reflects (inversely) the number of times that unit has been previously selected. So, if a sampling unit were not selected in any of the first P surveys from frame L, it should have a greater probability of being selected than a sampling unit which has been selected

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[2] Italicized numbers in parentheses refer to items in References at the end of this article.

one or more times in any of the first P surveys. Therefore, we want to assign probabilities $\pi_0, \pi_1, \ldots, \pi_M$ to each of the frame members that have been selected $0, 1, \ldots, M$ times such that π_j is the probability that each element that has been selected j times will be selected on the P+1st survey. Thus, the probabilities π_j should be monotone decreasing and should satisfy the following equation:

$$\pi_0 > \pi_1 > \ldots > \pi_M . \tag{1}$$

Also, to have a probability mass function to sample from, the following equation holds:

$$\sum_{j=0}^{M} \gamma_j \pi_j = 1. \tag{2}$$

To satisfy equation (1) and to allow the selection procedure to determine how much more likely the sampling units that occurred j times are to be in the P+1st survey than the sampling units that occurred i times, $j < i$, the following set of equations must hold:

$$\begin{aligned} \pi_0 &= a_0 \pi_1 \\ \pi_1 &= a_1 \pi_2 \\ &\ldots \\ \pi_{M-1} &= a_{M-1} \pi_M , \end{aligned} \tag{3}$$

In equation (3) the a_j's are constants greater than 1. Rewriting each probability in terms of π_M gives the following:

$$\begin{aligned} \pi_0 &= a_0 a_1 \ldots a_{M-1} \pi_M \\ \pi_1 &= a_1 a_2 \ldots a_{M-1} \pi_M \\ &\ldots \\ \pi_{M-1} &= a_{M-1} \pi_M \end{aligned} \tag{4}$$

That is,

$$\pi_i = \left(\prod_{j=i}^{M-1} a_j \right) \cdot \pi_M$$

Substituting these values into equation (2) gives the appropriate probability associated with all sampling units in the frame that have been selected M times in the first P surveys:

$$\pi_M = (\gamma_0 a_0 a_1 \ldots a_{M-1} + \gamma_1 a_1 a_2 \ldots a_{M-1} + \ldots + \gamma_{M-1} a_{M-1} + \gamma_M)^{-1} . \tag{5}$$

Using equations (5) and (4) gives the desired probabilities associated with the other units in L.

Up to now, the choice of the a_i's has been rather arbitrary because only equations (1) and (2) must hold. However, if we assume that the first P surveys were conducted so that each element of L had equal probability of selection π, then equation (1) should be rewritten as:

$$\pi_0 > \pi > \pi_1 > \ldots > \pi_M . \tag{6}$$

We would choose the a_i's so that equation (6) holds.

Example One

The following example illustrates the method of determining the selection probabilities π_j. Suppose the frame L contains N = 200 sampling units. Four surveys have been conducted and, for definitiveness, simple random samples of size 20, 20, 25, and 30 have been selected. Of the 76 (distinct) sampling units that have been selected, 1 was selected on 3 surveys, 17 on 2 surveys, and 58 on 1 survey. Thus $\gamma_0 = 124$, $\gamma_1 = 58$, $\gamma_2 = 17$, and $\gamma_3 = 1$. Let π_3 be the probability of selecting any element that was selected three times in the four surveys. For equation (6) to hold, where $\pi = 0.005$, and if three other conditions occur, equation (4) implies $a_0 = 10/7$, $a_1 = 7/5$, and $a_2 = 50$. The three conditions are these: the probability associated with any unit that was not selected (π_0) is 100 times π_3; the probability associated with any unit selected once (π_1) is 70 times π_3; and the probability associated with any unit that was selected twice is 50 times π_3. Equation (5) becomes:

$$\pi_3 = (17311)^{-1} = 5.77 \times 10^{-5}$$

and

$$\pi_0 = 100/17311 = 5.77 \times 10^{-3}$$

$$\pi_1 = 70/17311 = 4.04 \times 10^{-3}$$

$$\pi_2 = 50/17311 = 2.89 \times 10^{-3}$$

If we examine the special case of $a_i = a$ for all i's, equation 5 becomes:

$$\pi_M = \left[a^M (\gamma_0 + a^{-1} \gamma_1 + \ldots + a^{-(M-1)} \gamma_{M-1} + a^{-M} \gamma_M) \right]^{-1} \tag{7}$$

When $a_i = 1$ for all i's and each frame unit has probability of selection $1/N$, equations (4) and (5) imply that $\pi_i = 1/N$ for all i's. Thus, we can attain a "minimum" spread on our new probabilities of selection for the remaining surveys by taking $a_i = a$ just larger than 1.

Also, note that for large N and $a > 1$, an approximation to π_M is given by:

$$\pi_M \simeq \left[a^M (\gamma_0 + a^{-1} \gamma_1) \right]^{-1} \tag{8}$$

For example, taking $a = 1.1$ in equation (8) gives a "minimum" spread as $\pi_3 = 3.86 \times 10^{-3}$, $\pi_0 = 5.66 \times 10^{-3}$, $\pi_1 = 5.14 \times 10^{-3}$, and $\pi_2 = 4.68 \times 10^{-3}$.

SELECTION PROBABILITIES FOR GROSS INTERVIEW TIME

In many instances, the number of contacts made with a person is less important than the total time of the interview. This characteristic is often the case when detailed expenditure-type data are collected. The following approach resembles those shown in the preceding sections.

Proposed Method

Again, suppose K surveys are conducted from the frame L. Let m_j, $j = 1, \ldots, K$ be the average gross time of interview for each survey. Define for each frame unit the total time of interview for the first P surveys by:

$$t_i = \sum_{j=1}^{P} m_j \chi_{ij}, \quad i = 1, \ldots, N,$$

where χ_{ij} is the number of times the ith unit is selected in the jth survey. Now group all frame units with the same t_i's, and, of course, include a group for those elements with $t_i = 0$. Let γ_j be the number of frame units in the same group wherein the index j runs over the groups. Assume γ_j takes the possible values $0, 1, \ldots, M$. Thus, the γ_j's are defined similarly to the approach in "Selection Probabilities for Number of Contacts." Similar calculations can be performed to obtain selection probabilities based on gross interview time. The example below illustrates this procedure.

Example Two

Suppose the situation of example one, but N = 600. Let the average time of interview for the four surveys be $m_1 = 1$, $m_2 = 0.5$, $m_3 = 3$, and $m_4 = 0.5$, respectively. Group 0 contains the number of elements that were not selected in any of the 4 surveys and, hence, each has $t_i = 0$ associated with it. Let Group 1 contain those frame units that have $t_i = 0.5$ associated with it. Groups 2, 3, 4, 5, and 6 are those frame units with a t_i of 1, 1.5, 3, 3.5, and 4, respectively. The number of frame units in each group is $\gamma_0 = 524$, $\gamma_1 = 27$, $\gamma_2 = 19$, $\gamma_3 = 5$, $\gamma_4 = 19$, $\gamma_5 = 5$, and $\gamma_6 = 1$. Using equation (8) and taking $a_i = 1.1$ for all i's gives:

$$\pi_7 = \left[(1.1)^7 (524 + (1.1)^{-1} 27)\right]^{-1} = 9.35 \times 10^{-5}$$

It follows that the remaining new selection probabilities are these:

$$\pi_0 = 1.82 \times 10^{-3}, \pi_1 = 1.66 \times 10^{-3}, \pi_2 = 1.51 \times 10^{-3},$$

$$\pi_3 = 1.37 \times 10^{-3}, \pi_4 = 1.25 \times 10^{-3}, \pi_5 = 1.13 \times 10^{-3},$$

$$\pi_6 = 1.03 \times 10^{-3}.$$

ESTIMATION

In the assumptions in the "Introduction," we restricted ourselves to *ad hoc* surveys. Since we have also assumed that $n N^{-1}$ is small, the estimator for the population total that is used with the above selection probabilities is as follows:

$$\hat{Y} = n^{-1} \sum_{i=1}^{n} \pi_i^{-1} y_i$$

with variance

$$V(\hat{Y}) = n^{-1} \sum_{i=1}^{N} \pi_i (\pi_i^{-1} y_i - Y)^2$$

$$= n^{-1} \left[\sum_{i=1}^{N} (\pi_i^{-1} y_i^2) - Y^2 \right]$$

This equation becomes zero if $\pi_i \propto y_i$; that is, $\pi_i = y_i / Y$. Thus, the success of the sampling schemes (in terms of more efficient estimation) rests on whether or not the "sizes" suggested are proportional to the item totals y_i. At least for the list of farm operators discussed above and for the situations described in the examples, this may not be unreasonable. However, empirical studies should be conducted to measure the proportionality.

If $n N^{-1}$ is not small, sampling without replacement is used with Horvitz-Thompson estimators (*3*) of the form:

$$\hat{Y}_{HT} = \sum_{i=1}^{n} \pi_i^{-1} y_i$$

to estimate the population total.

Here, recall that $\hat{Y}_{HT}$ may have an estimated negative variance. However, as outlined in (*3*), various techniques have been proposed to minimize this problem.

CONCLUSIONS

Two methods of determining selection probabilities that reduce respondent burden have been presented. The first method gives probabilities based on the prior number of previous contacts. The second method is based on the gross interview time involved in previous contacts. It should be clear that the schemes presented can be generalized in two ways. First of all, the extension to stratified designs is easily made by computing selection probabilities for each stratum. Secondly, if one develops a more complex index of respondent burden, it can be applied as suggested in "Selection Probabilities for Gross Interview Time."

These methods of determining selection probabilities were developed for two reasons:

- To reduce respondent burden.
- To retain the probability concept behind the survey.

Thus, a fundamental concept behind probability sampling must be retained; each sampling unit in L must have a known *positive* probability of selection for each of the K surveys. The methods presented ensure that this concept is retained.

The procedures presented can be used in the total planning of surveys that are to be conducted by an agency. Suppose the "important" surveys are identified. By selecting the samples for these surveys at the beginning of the reference time period, analysts can apply procedures to the potential number of contacts or the potential total interview time per respondent.

Finally, further research is called for because empirical studies must be conducted to evaluate the efficiency of the pps estimator that would be used and that could be applied to stratified samples.

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IN EARLIER ISSUES

When designing a survey, the technical sampler usually tries to achieve the minimum sampling error consistent with a given cost or he tries to obtain a specified sampling error at a minimum cost. This is the principle on which much of the research work on sampling methods has been based. . . . To apply the principle, costs and sampling errors of alternative methods are needed. But the principle of minimum sampling error per dollar is not entirely satisfactory, for it deals with only one of two major components of error in survey results and furnishes no answer to the question of how much different degrees of accuracy are worth.

Earl E. Houseman
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January 1949

COMMENT ON "EFFECTS OF AN EXCHANGE RATE CHANGE ON AGRICULTURAL TRADE"

By Maury E. Bredahl and Paul Gallagher[1]

Effects of devaluation are examined for a one-commodity, two-region case. A percentage change in price of the commodity will not exceed a percentage change in the quantity traded of the commodity. A change in quantity traded could be large, even under the assumption that underlying supply and demand relations are inelastic.
Keywords: Exchange rate, agricultural trade, exchange rate elasticities.

INTRODUCTION

Increasingly, authors in agricultural economics are focusing on changes in exchange rates and the impacts on agricultural trade. Recently, Kost examined potential price and quantity effects of such changes. He drew implications for agricultural trade, assuming that the underlying supply and demand curves were inelastic (*1*).[2] He concludes the following:

> In summary then, we can only expect a small impact on agricultural trade due to any change in exchange rates. And what effect there is will be primarily a price effect rather than a quantity effect. The maximum change in either price or quantity traded will be equal to the same percentage change as the exchange rate change . . . to the extent that there are conditions that restrict the free flow of goods internationally, the impact on agricultural trade will be substantially less than this maximum.

THE OBJECTIVES

In this article we extend Kost's analysis by developing (1) an alternative graphic approach to exchange rate analysis and (2) quantitative measures of changes in equilibrium price and quantity due to an exchange rate change. Sufficient conditions are developed under which the percentage change in quantity traded exceeds that of equilibrium price. The conditions necessary for the percentage change in quantity traded to exceed the percentage change in the exchange rate are identified. Kost appropriately concludes that the effects of an exchange rate change depend on the elasticities of the underlying excess demand and supply relationships. However, we believe, contrary to Kost's assumption, that these relationships may be relatively elastic.

AN ALTERNATIVE GRAPHIC APPROACH

The figure shows the effect of an exchange rate change on equilibrium price and quantity using the traditional two country-one commodity closed system of Kost.[3] Kost's analysis is modified by the addition of a currency exchange sector. The trade sector is measured in dollars; changes in the export supply (U.S.) and import demand are shown from the U.S. position.

Initially, the value of one dollar is assumed to equal one foreign currency unit; that is, an exchange rate (γ) of one. In this case, the export supply (ES) and import demand (ID) curves, measured in dollars, represent the difference between the domestic supply and demand curves at each price (see the figure).

The devaluation of the dollar (exchange rate down from 1 to 0.5) rotates the import demand curve upward to the right. This rotation around the intercept represents a proportional change in that curve. The construction of the linear import demand curve requires only two price-quantity points. Because currency adjustments do not change the intersection of the curve with the quantity axis, only one additional point is needed. The logical point is the price in foreign currency at which import demand is zero, FP_O. This price in foreign currency units is translated into dollars through the following step. The dotted line originating at the intersection of supply and demand (Kost's isolation equilibrium price) in the foreign country is traced through the currency exchange sector to the 45 degree line (OA), and it is moved perpendicular (up) to the ray representing the appropriate exchange rate (OB). In this manner, the shift in the import demand curve from ID to ID′ is determined.

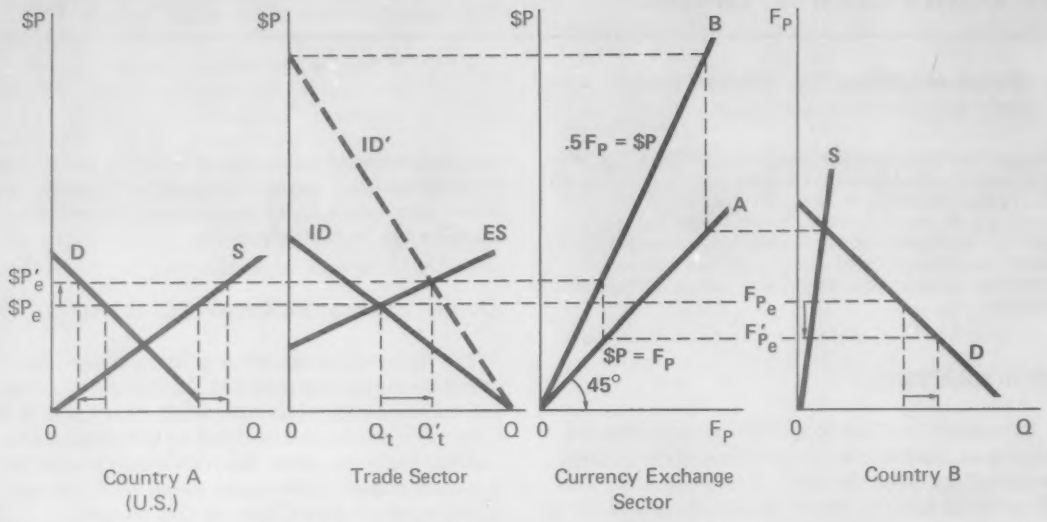
As depicted in the figure, the equilibrium price in the exporting country increases ($\$P_e$ to $\$P'_e$), quantity traded increases (Q_t to Q'_t), and the equilibrium price in the importing country decreases (FP_e to FP'_e). (Changes in quantities supplied and demanded in the two countries are indicated by arrows.) This graphical

[1] The authors are agricultural economists with the Commodity Economics Division, ERS. They thank Mary Ryan, J. P. Houck, Martin Abel, Abner Womack, and Wayne Boutwell for helpful comments.

[2] Italicized numbers in parentheses refer to items in References at the end of this article.

[3] The model assumes zero transportation costs; competitive, unrestricted markets; and a homogeneous commodity. For a more complete discussion, see (*2*).

Effect of a Currency Readjustment*



** The case depicted holds for a devaluation by the exporting country or a revaluation by the importing country. Arrows indicate the magnitude and direction of changes.*

presentation is conceptually more straightforward than Kost's approach of relabeling the price axis and shifting domestic supply and demand curves. The figure permits evaluation of the impacts of either a devaluation of the exporting country's currency or the revaluation of the importing country's currency; they are identical. In a partial equilibrium model, the domestic supply and demand curves are not shifted by a change in the exchange rate. The only curve which shifts is the import demand curve.

A QUANTITATIVE APPROACH

We now provide an algebraic development equivalent to the case depicted in the figure to develop measures of changes in equilibrium values. Translating the importing country's import demand function into the currency units of the exporting country (dollars) entails multiplying the slope of the excess demand curve by the appropriate exchange rate. The trade sector is expressed in dollars; therefore, the appropriate exchange rate (γ) translates foreign currency units to dollars.[4] The excess demand and supply relationships measured in dollars are

$$Q_{ed} = a_2 + [\beta_2 \gamma] \ \$P \qquad (\beta_2 \leq 0)$$

$$Q_{es} = a_1 + \beta_1 \ \$P \qquad (\beta_1 \geq 0)$$

$$Q_{ed} = Q_{es}$$

The effect of an exchange rate change is determined by totally differentiating each equation and solving for the appropriate differential. The total differential of the price in dollars is:[5]

$$d\$P = \frac{\beta_2}{\beta_1 - \gamma\beta_2} \ \$P d\gamma$$

The numerator of this expression is negative, the denominator positive; hence, the resulting quotient must be negative. The devaluation of the exporting country's currency is expressed by a decrease in γ (from $\gamma = 1$ to $\gamma = 0.5$; $d\gamma = -0.5$); therefore, a devaluation must increase the dollar price of the commodity.

The effect may also be expressed as an elasticity. The net or reduced form elasticity of the equilibrium price for the exchange rate is:

[4] The exchange rate measures the number of foreign currency units which can be purchased by $1. The value of the exchange rate, expressed in this manner, will decline if the foreign currency is revalued or the dollar devalued.

[5] When more general excess demand and supply functions are linearized with differentials, the same result holds, except that β_1 and β_2 are replaced by the appropriate partial derivatives. The algebraic expressions that follow them hold for more general demand and supply functions.

$$E_{\$P,\gamma} = \frac{-1}{1 - \frac{\eta_{es}}{\eta_{ed}}}$$

where η_{ed} is the price elasticity of excess demand and η_{es} is the price elasticity of excess supply. This net elasticity is bounded by 0 and -1. Therefore, the percentage change in equilibrium price will, at the most, equal the percentage change in the exchange rate.

The excess supply curve does not shift; therefore, the elasticity of the equilibrium quantity for the exchange rate becomes:

$$E_{q,\gamma} = E_{\$P,\gamma} \cdot \eta_{es}$$

$$\text{or } E_{q,\gamma} = \frac{\eta_{ed}\,\eta_{es}}{\eta_{es} - \eta_{ed}}$$

Multiplying the net elasticity of the equilibrium price for the exchange rate and the price elasticity of the excess supply function yields the elasticity of the equilibrium quantity for the exchange rate. Logically, this elasticity, which is negative, is bounded on the upper end by zero *but it has no lower bound*. Depending on the elasticities of the excess supply and demand relationships, this net elasticity may be less than -1; the percentage change in equilibrium quantity may exceed the percentage change in the exchange rate.

The net elasticities developed above can be used to examine two of Kost's conclusions: (1) that the price effect will exceed the quantity effect and (2) that trade impacts of an exchange rate change will be relatively small.

The size of the quantity effect relative to the price effect is determined by comparing the net elasticities developed above. The quantity effect will be larger than the price effect if the absolute value of the net elasticity of equilibrium quantity exceeds that of equilibrium price:

$$\left| E_{q,\gamma} \right| > \left| E_{p,\gamma} \right|$$

$$\text{or } \left| \frac{\eta_{ed}\,\eta_{es}}{\eta_{es} - \eta_{ed}} \right| > \left| \frac{\eta_{ed}}{\eta_{es} - \eta_{ed}} \right|$$

Therefore, the sufficient conditions for the percentage change in quantity traded to exceed that of equilibrium price are that the elasticity of the excess supply relationship be greater than one and the elasticity of the excess demand relationship not be zero.

The question of the absolute size of price and quantity effects is somewhat more difficult to answer. A "large" exchange rate effect occurs when the percentage change in quantity traded exceeds that of the exchange rate. This definition of a large exchange rate effect requires that the net elasticity of quantity traded with respect to the exchange rate exceed one. The net elasticity of quantity traded will be elastic (net elasticity greater than one) if the product of the absolute values of the excess relationship's elasticity exceeds the sum as shown below.

$$\left| \frac{\eta_{es}\,\eta_{ed}}{\eta_{es} - \eta_{ed}} \right| > 1$$

$$\left| \eta_{es}\,\eta_{ed} \right| > \left| \eta_{es} - \eta_{ed} \right|$$

This relationship implies that if the absolute values of the excess elasticities are equal, the absolute value of each must exceed two for the net elasticity to exceed one. If the elasticities are unequal, each must be greater than one. These elasticities must be determined empirically.

The crucial theoretical question in determining the size of price and quantity changes becomes the elasticity of the excess relationships. Kost argues that agricultural commodity supply and demand relationships are inelastic; therefore, the quantity effect of an exchange rate change must be small. However, noting that the underlying domestic supply and demand relationships are inelastic is not sufficient evidence to conclude that excess supply and demand relationships are inelastic. Recalling that the quantity effect will exceed the price effect if the elasticity of the excess supply curve is greater than one, we now develop the elasticity of that relationship. Following Kost, the price elasticity of the excess supply relationship may be written:

$$\eta_{es} = \eta_s \cdot (Q_s/Q_x) - \eta_d (Q_d/Q_x)$$

where η_d and η_s represent the price elasticities of domestic demand and supply, Q_d and Q_s represent domestic quantities supplied and demanded, and Q_x represents the quantity exported. (Note that $Q_s - Q_d$ equals Q_x and that η_d is necessarily negative for downward-sloping demand curves.) The excess supply elasticity may be elastic even if the underlying supply and demand relationships are inelastic. For example, if one assumes the absolute value of both elasticities is 0.5, quantity demanded and supplied are 75 and 150, respectively, the elasticity of the excess supply function will be 1.5. In all cases, the elasticity of the excess supply curve will never be smaller than the elasticity of the domestic supply function. They will be equal if $Q_s = Q_x$. Note also as the percentage of supply exported decreases, the elasticity of the excess supply function increases. A similar type of analysis indicates that excess demand curves may be elastic, which suggests that exchange rate effects on quantity may be large even though domestic supply and demand relationships are inelastic.

Further theoretical justification for the hypothesis that the demand for U.S. exports is elastic is found by analysis of the elasticity of the export demand for U.S. agricultural commodities. Export demand is defined as the difference between the sum of the excess demand of all importing countries and the excess supply of all export demand relationships as shown below:

$$XUS = \Sigma_i ID_i - \Sigma_j ES_j$$

(XUS equals export demand for a U.S. commodity, ID_i equals import demand of ith importing country and ES_j equals export supply of jth exporting country.) Substituting linear relationships for all excess relationships,

$$XUS = \Sigma_i(a_i + b_i\gamma_i P)$$

$$- \Sigma_j (a_j + b_j\gamma_j P) \quad (b_i \leq 0; b_j \geq 0) .$$

Holding all exchange rates between all countries constant (γ_i, γ_j) and totally differentiating, one obtains:

$$dXUS = \Sigma_i b_i dP - \Sigma_j b_j dP .$$

Expressing the differential as a net elasticity yields:

$$E_{xus,p} = \Sigma_i \eta_{ed_i} \frac{Q_i}{Q_{xus}} - \Sigma_j \eta_{es_j} \frac{Q_j}{Q_{xus}}$$

Q_i/Q_{xus} and Q_j/Q_{xus} are the proportion of ith country's total imports from the United States and exports of the jth country as a proportion of U.S. exports, respectively. If one assumes the absolute value of all elasticities is 1.5 and that the United States accounts for half the agricultural trade of the commodity, the elasticity of the U.S. export demand function is -4.5. Therefore, the elasticity of the export demand for U.S. agricultural commodities may be much larger than the elasticities of the underlying excess demand and supply relationships. These, in turn, may be more elastic than the underlying domestic demand and supply relationships.

CONCLUSIONS

From the algebraic analysis of the free trade model, we can conclude that:

- The percentage change in equilibrium price and quantity depend on the elasticities of the excess supply and demand relationships. The percentage change in equilibrium price will not exceed the percentage change in the exchange rate; the percentage change in equilibrium quantity traded may or may not exceed the percentage change in the exchange rate.
- The percentage change in quantity traded will exceed that of the price change if the elasticity of the excess supply function exceeds one.
- The elasticities of excess supply and demand relationships may be elastic even if the underlying domestic supply and demand relationships are inelastic.
- Given elastic import demand and export supply relationships, the percentage change in quantity traded due to an exchange rate change may be quite large.

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RESEARCH REVIEW

IN THIS ISSUE

The idea of progress had a grip on Western thought during the 18th century. Consequently, people then tended to regard change as leading steadily toward a better world. Malthus, in pointing out that population growth might outrun the food supply, was among the few who saw limits to progress. Nineteenth century technology pushed the limits aside, and the idea of progress remained alive and well as twentieth century agricultural technology advanced.

Consequently, agricultural economists have largely tended to be complacent about U.S. agriculture's capacity to produce food and fiber. In our first article, Spielmann finds this complacency reflected in a sparsity of both theoretical and empirical studies of agricultural capacity. His review of the literature shows the difficulties of defining and measuring capacity. He also reviews some ideas from the nonagricultural sector that could help to remove some of those difficulties.

The burden of innocent citizens who find themselves repeatedly drawn in researchers' random samples forms the topic of Tortora's article. This burden could be shared more equally without destroying the statistical randomness of the sample. A respondent contacted in previous samples could be assigned a lower probability of being drawn than one who had not been queried. Persons whose names appear on lists from which researchers draw repeated samples will welcome the author's suggested procedures.

The third article extends ideas presented in the July 1976 issue of this Journal in which Kost presented a novel, graphic method for analyzing international trade responses to devaluations and revaluations. Authors Bredahl and Gallagher put forth a simplifying refinement of the graphic analysis. In addition, Kost assumed that if domestic demands on two trading countries were inelastic, the net export function would also be inelastic. That conclusion does not necessarily follow, according to arguments presented here. Even though domestic demands are inelastic, the net demand function in the international trade sector can, in principle, be either inelastic or elastic. Consequently, the change in quantity traded in response to small changes in exchange rates can, in principle, be either relatively small or large.

In rereading earlier issues of this Journal, we have found a number of excerpts which may prove interesting to you. Some exhibit lasting value, some complement or contradict current articles, and some are just for fun. The passages reproduced this month come from our first issue, in January 1949.

CLARK EDWARDS

AGRICULTURAL-FOOD POLICY REVIEW

Economic Research Service, U.S. Department of Agriculture. ERS AFPR-1. 138 + ii pages. 1977.

This review reflects the personal assessment of a professional staff member using the information in the congressional process. It does not, however, speak for the Congress, the House Budget Committee, or all congressional staff members. Time and space requirements do not allow a separate review of each article; consequently, I will give a general assessment of the cumulative impact from this report.

Agricultural-Food Policy Review significantly improves analytical information available to us for reviewing agricultural legislation. Members of the Congress or its staff may review, under one cover, analysis of all the major commodity issues facing this session. Further extensions of these studies, however, could fulfill additional needs.

I expect new or junior legislators will read this publication to gain an overview of agricultural-food problems. Agriculture committee members will read specific articles as they address particular problems in their hearings and as they are writing a new bill. Senior members of the agriculture committees may seek familiarity with the publication, but the articles will probably not offer enough new facts to justify the time for a close reading.

Agriculture committee staff and members will use the publication for ideas on questions at hearings. Staff members not trained in agriculture will want to read the *Review* closely to understand the history and complexity of agricultural problems. Experienced staff members will not turn to this publication for answers but for help in framing the questions. The individual articles should suggest expert economists that can be contacted for further help. The charts and tables provide excellent resource material. Staff for the budget committee will find budget and economic implications in some articles.

Articles in the *Review* cover many of the issues expected to be important in the forthcoming farm program debate. The *Review's* authors describe the policy process; project likely political climates; analyze the implication of failure to pass a new bill; consider the concepts of cost of production, support mechanisms, land and grain reserves, and disaster protection. They interpret possible changes in the rice, peanut and extra-long-staple cotton programs; outline the livestock-grain policy connection; and discuss the international implications of U.S. food policy. With the exception of food stamps, the resolution of these issues will likely determine the structure of the farm bill. The magnitude of each issue should, however, depend on the participation of the various interests in a coalition to pass a bill.

Essential questions and basic intra-agricultural relationships are discussed. Review of the 1973 farm bill highlights worldwide developments in the grain and livestock economies. Analysis of the cost of production outlines the differences among the several measurements. The grain reserve article presents a discussion of alternative management mechanisms in the context of economic stability. The current crop disaster program is compared to a possible expansion of the Federal Crop Insurance Program. And the relationship between livestock and grain is explained to show the implications of grain programs on livestock even without direct policy participation by beef and pork producers.

However, several important policy issues are ignored;

such as, changes in dairy, tobacco, and sugar. Changes in these programs could very well emerge as the most controversial or most expensive in the next year. What, for example, is the cost of raising the milk support price from 80 to 85 percent of parity? What is the impact of expanding the transferability of tobacco allotments? What are the economic costs for sugar producers of growing other crops and what are the alternatives to domestically grown sugar? The Congress will be looking to the Department of Agriculture for analysis on these and related issues.

The issue of agricultural finance requirements is not treated. The Congress has incrementally provided a broad array of loan programs to farm producers, rural residents, and others. A guaranteed loan program for livestock farmers or an expansion of farm ownership loans may affect food prices more than any change in target prices, which are analyzed in the report. The growing number of Government lending programs also need further examination.

The budget costs of permanent legislation are not analyzed. Technically, the Budget Act of 1974 requires analysis of the change in budget costs from new legislative bills. Consequently, a cost analysis of proposed bills should reflect not only the total costs of the bill but the difference between costs from the proposal and costs if no new legislation is adopted. The article analyzing a reversion to basic legislation discusses the complexity of an assessment of budget costs, but an actual cost estimate is needed. Economists could meet this requirement by assessing minimum and maximum costs under the basic legislation, making judgements on crop acre slippage and other factors.

The *Review* helps the reader understand implications to producers of agricultural policy, but it fails on implications for consumers. Members of the Congress and their staffs will want to know retail price changes for all food and for specific key commodities. USDA researchers have been reluctant to invest in analytical improvements of farm-to-consumer relationships. Often, horrendous assumptions are necessary to analyze the retail impact of raw farm products. These questions will still be asked, however, and USDA experts are in a better position to make these judgements or assumptions than anyone else.

Some understanding of the mechanics of the policy process is lacking. The articles quite nicely direct attention to important questions, but the Congress may approach the issues from another direction. For example, authors of the first article draw attention to the importance of the appropriations committee; however, they fail to point out that the agriculture programs discussed in the *Review* are entitlements funded outside the appropriations process. The international issues discussed in the last article contain no analysis of the congressional issue of restricting 75 percent of the P.L.-480 program to countries with under $300 average annual income.

Publication of these articles represents a step in the right direction. Economic Research Service economists have prepared a clear and concise analysis in a timely manner. Continuing this effort with more emphasis on answering the questions raised in the articles and the new congressional questions will further facilitate the legislative process.

Allen Grommet
Agricultural Analyst
Budget Committee
U.S. House of Representatives

WORLD SOYBEAN RESEARCH

Lowell D. Hill, ed. The Interstate Printers and Publishers Inc., Danville, Ill., 1073 pages. 1976. $16.50.

This portly volume contains the proceedings of a 5-day World Soybean Research Conference held in Champaign, Illinois, in 1974. The conference sponsors were the University of Illinois, the Illinois Natural History Survey, USDA, the Agency for International Development, and the National Soybean Crop Improvement Council. The book's editor, Lowell Hill, an agricultural economist at the University of Illinois, performed the remarkable task of wrestling 106 individual manuscripts into a single, well-organized collection of papers displaying a common format and, as far as I can tell, a consistent editorial style.

Five major subject headings divide the papers: production, protection, economics of marketing and production, utilization, and summing up. All but the last are further subdivided into more specific research fields and subject matter areas. As is typical with reference works of this kind, the papers range from highly technical presentations suitable for professional journals to offhand remarks more appropriate for afterdinner speeches. In fairness, the former far outnumber the latter in this collection.

The publisher's blurb declares this to be "an authoritative work that should be in every agricultural library." That is right. It is the latest in a reasonably long line of modern professional monographs cataloging the science, technology, and, more recently, the economics of the soybean (*1* through *4*).[1] The papers in this particular collection are short; they average slightly under 10 pages each, the shortest being 3 pages and the longest, 28 pages. Hence, they tend to be highly specialized summaries of ongoing and completed research, bristling with scientific literature citations, diagrams, and tables. A few selections are overviews, some based on rearrangements of USDA and FAO data.

Anything said in a review of a collection of 106 papers is bound to be general, with few specific comments. But consider the book from the viewpoint of an economist. Unless one has a specific technical interest in some aspects of soybean production or protection, the scientific overviews published in the recent American Society of Agronomy (ASA) monograph (*1*) are probably more helpful. For example, the ASA monograph has a single chapter devoted to insect damage and control in

[1] Italicized numbers in parentheses refer to items in References at the end of this review.

soybeans. *World Soybean Research* features 12 papers on soybean insect problems—a boon to the graduate student in entomology but possibly bewildering to others. The same observation generally applies to the other eight subareas in the production and protection sections, which span some 640 pages. Yet this is not a book of overview articles; it is a compilation of research reports. So the book's value depends on the reader's interest in specific research issues.

What about the 14 papers in the economics of production and marketing and the 19 papers on human and animal utilization of soy products? Of the 19 papers, authors of 11 focus on chemical and nutritional questions somewhat beyond the general interest range of most economists. Consequently, about 22 papers in the book are of obvious general interest to economists.

Three papers by S. C. Schmidt, D. G. Frahm, and A. S. Walter, respectively, deal with world trade and competition. Price and policy relationships are the focus for four papers by J. Vermeer, R. S. Golden, T. A. Hieronymus, and R. A. Hinton, respectively. The Vermeer paper is an especially useful summary of government policies affecting the soybean sector both here and abroad. Seven papers concerning the soybean processing, storage, and transportation sectors are included, by W. J. Free, C. M. Christensen, H. H. Kaufman, H. J. Barre, G. C. Shove, L. D. Hill, C. J. Nichols and W. A. Bailey. Free's paper provides a good, terse overview of the location, type, and size of U.S. soybean processing plants.

In the utilization area, F. E. Horan looks at the use of soy protein for food, W. W. Craven and R. J. Herder discuss uses of soy protein in feed, and G. W. Kromer considers trends in soybean oil use. A paper by O. B. Smith provides a reasonably clear, fairly nontechnical, illustrated discussion of the new textured vegetable proteins and meat analogs.

If your favorite topic in soybean research is not covered in the book, it is probably because it was not included as an invited paper in the conference. However, there is a good chance that such a topic will be among the 52 contributed papers whose titles and authors are listed at the back of the book. Names and addresses of the more than 600 conferees and authors are also given.

If you make decisions for an agricultural library, buy this book. If you collect all things written about soybeans, buy this book. If you have a professional interest in soybeans and related products, borrow this book to see if it contains enough to interest you in purchasing it. There may well be, but surely there is no one alive who will understand everything in it.

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THE POLITICAL ECONOMY OF NATURAL RESOURCES POLICY

As I look back on our natural resource history, I see only plenty. People, with their accumulated knowledge and capital, were the restraints on our advancing welfare, not natural resources. True, there has always been, at each moment in time, an economic margin restraining increased economic use of space, land, timber, forage, water, ores, coal, petroleum, and air. But advances in technology always saved the day so that natural resources never became a restraint.

Technological changes bearing directly on available resources occurred in (1) exploration and discovery and (2) access to and extraction of discovered and known resources. These changes have been overshadowed by technological changes that indirectly increased productivity of labor and capital. It has become an article of faith that technology will always save us.

The socio-politico-economic institutions concerned with natural resources, and the sociocultural system of values and relative preferences we evolved, exploited these natural resources. No harm in that, so long as resources were abundant. But that abundance began to change to scarcity during the first decade or two of this century. The changes broadened slowly and increased gradually between the two great wars and then accelerated markedly. Yet, as recently as 1963, Professors Barnett and Morse, in a trenchant book that greatly influenced me and my students, argued that natural resources were not then and will not for a very long time, if ever, be constraining on growth or welfare (*1*).[1]

Barnett and Morse related their optimism only to the supply of marketable goods and services derived from nature. They argued that the "quality of life" could—and probably would—be affected adversely, particularly by space and energy shortages. As Norgaard (*9*) says:

> We are neither so naive nor confident today. The environmental crisis, the Arab oil embargo, and the subsequent reanalyses of our resources, technologies, and institutions have swept us over an awareness threshold toward the "economics of the coming spaceship earth" (*3*). [W]e have not developed satisfactory methods of adjusting our actions in light of this now widespread consciousness. . . . [O]ur concern over scarcity and growth today is based on the long-standing

[1] Italicized numbers in parentheses refer to items in References at the end of this note.

issue as to whether we are developing technologies as fast as we are depleting high-grade resources.

Within the U.S. economy, increasing scarcity of space, energy, water, and air, ubiquitous in their influence on all production and consumption of material goods and services as well as on the quality of life, is in prospect because of the following:

1. A continuous growth in population numbers together with accelerated change in their distribution among urban, suburban, and rural geographic regions.
2. A rapid and accelerating rise in per capita real incomes, especially among the lower and middle income classes.
3. An accelerating rise in the levels of technology applied to the direct conversions, hence, consumptive use, of natural resources in the production of marketable material goods.
4. An increase in demands for: marketable material goods; services and amenities derived directly from natural resources; energy; and the direct services of land, water, and air as dumps for unwanted endproducts.
5. A relatively slow rate of change in the technologies or relative preferences that save or expand space, that save or increase energy, or that increase the waste recycling or absorptive capacity of air, water, and land.

These changing conditions generate several broadly distinguishable kinds of socioeconomic problems. First, there is an increase in rents (input costs) for space, energy, water, and air. Rents rise because of (1) scarcity, (2) opportunity costs as demands proliferate, and (3) increased domestic dependence on uncertain foreign sources.

Second, accelerating rates of depletions of particular natural resources may, in turn, generate immediate or longrange increases in resource rents through changes in quantity, quality, accessibility, or location.

Third, rising resource rents shift the distribution of real incomes and wealth toward the middle and upper economic classes.

Fourth, existing institutions and the "rules of the game" generally presuppose "free" to "low cost" resources, and they even may be designed to insure that resources will remain free or low cost to their private sector users or managers despite rising social costs.

Fifth, low private (relative to social) costs may (a) cause resources to be exploited too rapidly and too broadly for optimum social gain, and (b) result in sunk investments (fixed costs, frozen assets) that will hinder conversion to resource conserving systems.

Sixth, after hundreds of years of gradual change (Webb refers to it as the "four hundred year boom," *10*, pp. 13-28), we have suddenly crossed Norgaard's "threshold of awareness." Problems are emerging faster than the system is able to adjust. We resist the problem of natural resource development by ignoring it, by refusing to see even when shown, by praying for deliverance, and by awaiting a crisis too severe to ignore with its attendant *ad hoc*, crash responses.

It would be typical for us to undertake economic analysis of emerging natural resource problems by applying conventional economic wisdom. That wisdom presupposes:

- An infinite supply of whatever resource may be in question, or an infinite supply of perfectly substitutable other resources;
- Today's structure of socio-politico-economic institutional environments—or worse, perfect competition and perfect markets;
- The current relative preferences for resource products and services among consumers;
- A projected rate of technological change;
- A projected rate of population growth;
- An objective function designed to maximize a unidimensional welfare goal.

From such a conventional model, analysts can, given adequate data, project the growth of GNP (sometimes accompanied by observations about the related growth of amenity services), the growth of GNP per capita, and possibly the distribution of GNP (and possibly of amenities) among socioeconomic classes. Doesn't that sound splendid?

But its splendor is a mirage, for we will be of little help to resource policymakers. We will have assumed away the problem. We will imply that whatever is, is both good and right, subject only to consideration as to the adequacy of knowledge. We will be saying to policymakers—all you need do is ensure that the channels of communication to resource managers and consumers are functioning adequately in order to "fine tune" natural resource use and consumer products. Using the model, the economist cannot predict exact outcomes, quantify objectives, or weigh uncertainties.

Most economists know of the all-pervading presence of externalities; neither the resource manager nor the product consumer maximizes social good, even though both may be individually and collectively seeking the most productive combinations. The problem's source lies in (1) the institutions that are involved in resource decisionmaking and (2) the goals and preferences of society. The answer to the problem lies not in conventional economic wisdom, but in political economy, law, government, social psychology, and ethics.

The fact that the problem needs solution within a wide context does not mean that economists should be replaced as analysts of natural resource problems. The economic content of the problem dominates. But economists engaged in natural resource policy analyses must become political economists, or institutional economic analysts, or, at the very least, must be flanked with political scientists, lawyers, and social psychologists. We need to purposively engineer changes in our institutions and our goals and preferences. It seems we must always be dragged kicking and screaming into such a process.

Boulding asserts that policymakers do not take as their objective the maximization of some "idealized social goal" or unidimensional goal. Rather,

> [policymaking] tries . . . to proceed from day to day in a direction it perceives as "up"—"up", for some strange reason, meaning "better" . . . . It brings us closer to realism when we abandon the "social goals" concept and concentrate simply on what might be called a "dynamic evaluation function", which is simply a way of trying to describe

> "which way is up". To those eagle-eyed soaring souls who want to base every action on some splendid glimpse of a distant glorious future, this may seem like chickening out. The awful truth is that most of us are chickens, not eagles (*4*, pp. 141, 142).

Boulding stands four-square with Professor Lindblom and "marginal incrementalism" (*8*) and Professor Wantrup and "safe minimum standard" in resource conservation policy (*5*). Boulding concludes:

> Fortunately for us, we have to leave most of these problems to our descendants. All we can really do is to wish them well, to leave them a little elbow room, and to guide our current evaluation functions somewhere toward the minimax of being on the safe side (*4*, p. 151).

We must shun policies that claim to lead our society over the one true path and substitute Boulding's concept of a "dynamic evaluation function," or what I would call an "up-function," the strategy of "upmanship."

Marginalism can lead us into perverse processes in which society becomes progressively worse off. " . . . we must look beyond incrementalism to some kind of long-range vision that can penetrate the fog to permit us to view more distant summits" (*2*, ch. 3, p. 67). We must hold some vision—or hope—of which route we think is up—even if we can't see it very clearly.

The institutions which guide economic change must incorporate "feedback" loops so that the system can learn from mistakes and adjust to change. The system can then make incremental corrections at those moments when the fog lifts enough to reveal error, or in which experience reveals that our course is actually downward.

This approach requires flexibility and reversibility. Preference must be given to institutions and policies that "leave future options open." Incrementalism together with built-in flexibility and reversibility in resource policies and institutions really represent pleas to grant freedom of choice to future generations—freedom curbed by the responsibility of each succeeding generation of analysts and decisionmakers.

Krutilla and others have considered the conceptual and methodological issues in analyses involving irreversibilities and uncertainties in natural environments (*6*; *7*). Krutilla and Fisher explore the following question:

> When a pristine natural environment has two alternative uses, one extractive and the other amenity yielding, each alternative being destructive of the other, which use should be assigned to the site, when in time should it be assigned, and by what analytical methodologies can guidance to the decision be given?

Choosing one alternative can close the option for the other. If you build a dam for water and power, you sacrifice amenity. If you open an ore body to gain minerals, you destroy a pristine wilderness. Krutilla-Fisher find the following issues crucial:

1. Asymmetric influence of technological change between commodity outputs and amenity services;
2. Impact of congestion on amenity services of pristine natural environments;
3. Differing economic costs of irreversibilities under uncertainty.

Their concept applies to any natural environment yielding an amenity service that (1) can be used only at the site, (2) can be destroyed by human beings if the site is used for commodity outputs, and (3) cannot be produced or, once destroyed, be reproduced by us.

The Krutilla-Fisher model, applied by them to a half-dozen real-world cases, revealed that the amenity alternative overvalued the commodity alternative in every case. Two flexibility costs vastly different in their impact on commodity compared with amenity production brought about this result. These costs are (1) the differing impact of technological change and (2) the differing costliness of reversibility. Reversibility will be cheap when shifting from the amenity to the commodity alternative. But it will be very dear, even infinitely costly, in attempts to shift from the commodity to the amenity alternative.

The Krutilla-Fisher analysis gives only passing and perfunctory attention to the changes in policy and administrative institutions that would ensure the amenity alternative would be evaluated in terms of the opportunity costs it imposes on commodities.

Resource policy analyses consist primarily of descriptions of alternative sets of institutions whose function is to guide, as by an "invisible hand," choices which will determine the content, purpose, rate, "where," and "for whom" of economic activity. Resource policy analyses examine which institutions to leave unchanged, which ones to modify and in what way, and what new ones to create. Institutions in resource policy analyses cannot be silent. They must be explicitly in, even at the center of, the analytic system. That is why Professor Wantrup has referred to resource policy analysis as "applied institutional economics."

This note summarizes the ERS Bicentennial Lecture delivered by M. M. Kelso on November 9, 1976. Dr. Kelso is Professor Emeritus at the University of Arizona.

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AGRICULTURAL PRODUCTION ECONOMICS IN THE FUTURE

Agricultural production economics is not a scientific or academic field which comes and goes with the "fads". It is and will remain a major field of graduate study, research, and extension. It provides a basis for defining problems, information, and relationships which need continuous re-estimation as markets, technology, and institutions change.

Most of the State universities retain agricultural production economics and farm management as a major field. It is not listed by name in the organizational chart of the Economic Research Service (ERS), which emphasizes problem areas. This problem emphasis is needed in an applied field wherein society has invested in the solution of problems. Strong demand for production economists is expected as the highly commercial farm strata continue to strengthen. While this potential is an intellectually exciting opportunity, it has its dangers.

Perhaps a study could be made of the impacts of economic research on groups other than the target group to which results are directed. Speakers at the 1976 AAEA meetings suggested that those conducting micro studies should follow through on the expected macro outcomes. Concentration on highly capitalized farms not only accelerates their development but it also causes disadvantages to fall on smaller farms and rural communities.

The production economists' interest in highly commercial farms has helped animal scientists, agronomists, and other technical scientists to understand and apply what they term systems analysis. This method provides a widening opportunity for cooperative efforts between economists and other scientists. Unfortunately, the physical separation of economists and technical scientists, or even other social scientists, serves somewhat as an obstacle for ERS personnel in engaging in joint activities.

At the firm and subfirm level, micro models developed and applied to guide managerial decisions should be kept current. So should macro or aggregative models. In earlier times, a single publication represented the end of the research activity. Now, many models developed will be continuously updated to provide a stream of solutions. This activity is already underway in several States; it is partly represented by the Federal Enterprise Data System (FEDS) budget generator of ERS.

However, this question can be raised: Does continued application of the model with additional data represent research? My inclination is to classify it as a useful activity which might best be carried on by the extension services or private firms. There is much greater need today for joint appointments of personnel to extension and research. The research portion might be used for the updating and extension of developed models, and the extension portion, for continued applications. This is a more pressing problem in land-grant universities than in ERS.

The overwhelming majority of models developed to aid farmer decisions have been static and deterministic. Recent developments have greatly increased price volatility and the uncertainty surrounding agriculture. The corn blight in 1971 and variable demand and weather conditions in the seventies illustrate this uncertainty. There is need for stochastic models.

The production potential of the Nation's agriculture has two important research facets. If concerns over the world food situation continue, one problem is how to better estimate our food supply capacity under various conditions of technology and land and water use. We need to know the investment required to bring land into production, and the supply price for food produced on each strata of the land. If growth in exportable surpluses mainly translates into livestock feed for rich countries, the basis for concern perhaps need not be great. If the goal is more food to the world's hungry and poor, and if extramarket institutions can be developed and implemented to accomplish this task, then we need to be concerned.

The second research facet relates to the policy means by which the hunger of the world's poor can be translated into effective demand, with prices at levels stable enough for U.S. farmers to profitably produce at the maximum. Both extramarket demands to feed 500 million hungry people and commercial market demands are highly uncertain. U.S. supply capacity likely is sufficient to meet export demands expressed through commercial markets. Prices can even be depressed in relation to the high-cost structure which has now been capitalized into agriculture. Stochastic microlevel decision models can be useful in treating price volatility and uncertainty to improve decisions and encourage greater output. Mostly, however, reduction of this uncertainty must come through grain reserve policies. Research to establish optimal grain reserve policies is a potentially more powerful alternative in reducing the uncertainty than is research on farmers' decisions.

Capital demand and farm financial and estate management need more research. The research momentum may be toward concentration on models, legal alternatives, and information about family corporations which leads to even larger and fewer farms. We have little parallel activity on the behalf of younger and smaller farmers. While the nonfarm corporation is posed as an evil giant

standing over agriculture ready to snatch control away, the more exact threat is the very large scale family farm.

A study in ERS by Pat Madden a few years back suggested that the major scale economies were attained by farm sizes falling far short of the level to which the largest of commercial farms now seem headed. Research in this realm could help revive rural development, especially in light of recent information on "backward migration" from urban to rural areas. Our initial study at Iowa State University showed larger and fewer farms to be associated with lower aggregate farm income, smaller input usage, and reduced nonfarm employment in rural areas. Of course, income per large farm is much higher and supply prices for agricultural commodities are lower.

Two elections back, it seemed that every presidential and congressional candidate had rural development as a major platform plank. Farmers, too, plugged for rural development programs—more or less equating them with higher support prices and greater farm income. With the recent upward burst in farm income, commercial farmers have fairly well abandoned interest in the unsolved problems of rural community welfare. "Front burner" problems have become those of energy, land prices, environmental controls, and urban encroachment on farmland.

Public programs affecting resources tend to involve either situations where there is strong competition among alternative users for land and water, or where there are externalities. More studies need to be initiated which measure fully the economic impacts of such programs. For example, the Environmental Protection Agency can specify the types of inputs and farming systems which can be used. We need to know the costs of these programs and to be able to identify those for which society should compensate farmers who are adversely affected. For farming practices long in use, where the resulting income stream has been capitalized into resource values, compensation from the public seems entirely appropriate if the input is condemned. However, development of a new input could promise increased yields but have a potential negative impact on the environment. Compensation is not required here if the input is condemned because the farmer would not have realized a sacrifice.

Public programs redistribute income and resource values within agriculture. For example, a program which limits soil loss to 5 tons per acre annually can reduce output and income in areas of the Southeast, where rain is abundant and soils are erosive. Such a program would not limit output in the Corn Belt and Great Plains, where land is level, rainfall is limited, and there is not an erosion hazard. In addition, because the supply of the first region is restrained, the latter regions gain through improved market prices.

At an earlier time, ERS kept data on a fairly complete set of "typical farms." These indicated the input, expense, and income by type of farm in different regions. These efforts have been in abeyance. A reinstitution would be highly complementary with the ongoing FEDS project, which provides production costs for a wide range of enterprises and locations, and with other types of farming data which ERS is again starting to collect.

Because of the high commodity price now capitalized into agricultural resources, I expect to see periods of pressure for price supports even with continued high exports. I see no reason why society should capitalize speculative prices into land values. In addition to payment limits, there is considerable consensus that income rather than price should be supported. The level and amount of these payments would best be based on results from studies of typical farms.

Production economics historically has involved macro studies. Early examples were represented by delineation of farming regions in terms of comparative advantage or supply response. Later, a massive supply response and comparative advantage study was made for milk over the Lake States and New England. It was inspired by Sherman Johnson and J. D. Black. It included farm response estimates which were aggregated into regional supply functions. Some three decades later, ERS cooperated with the North Central and New England States in somewhat parallel studies emphasizing dairy, pork, beef, and closely competitive products. Farm estimates were aggregated into State or regional responses. Later, ERS launched a fairly large-scale national model project, but this effort seems to have faded away. Similarly, the methodological and quantitative interest in econometric supply response estimates in the fifties and sixties has also faded away.

The basic world food problem renews the need for supply response estimation. Models need to consider supply prices on lands not now cropped if production is carried to successive levels. Though often implied, it is not true that the world's ability to produce food follows a supply function which is horizontal at the outset, but vertical at some posed capacity. Rather, the quantity supplied depends on the price that consumers or some world institution can pay for food. With wheat and corn at $10-$12 per bushel for an extended period of time, we could have much more food available for human consumption.

There is need to review our supply capacity and response in relation to two areas:

- Export capability under normal commercial markets and somewhat volatile export demands;
- Potential contributions to world food supplies.

At Iowa State we have been developing and applying models which provide supply estimates on an aggregative regional basis. We, in fact, started this as a cooperative project with ERS—which withdrew from it in a fairly early stage. However, we are again engaged in a large-scale cooperative effort with ERS and the Water Resources Council in analysis for the National Water Assessment Study. These longrun models assess production potentials and supply prices based on regional, rather than farm, restraints. They reflect regional comparative advantage and resource capabilities.

A considerable number of national "econometric" and simulation models have been developed. It would be convenient if these models could be disaggregated to provide results at least by the major producing regions. ERS is close to the data base and is the appropriate place to locate such models. Regional disaggregation and partitioning of national simulation models is a needed counterpart to the call for extension of micro models so that their macro implications can be better understood.

Agricultural production economics is a broad field encompassing all aspects of production and resource use related to agriculture. Some 25 years ago I titled one of my books *The Economics of Agricultural Production and Resource Use*. I made this choice because a common set of economic concepts and quantitative methodologies surround the analysis, which can be applied to various subsets of phenomena, such as farm optimization, estimation of commodity supply functions, or resource economics. Specialization in agricultural economics is now largely disappearing as graduate training becomes more generalized in the application of basic economic principles and quantitative methods. The task ahead is to amass sufficient labor and skills around a particular problem, as reflected in the organization of ERS, so that the problem's many facets and particular data needs can be examined. Large-scale quantitative undertakings can link the various levels of aggregation and sets of economic relationships. Team research will be needed if analysts are to exploit possibilities in linking commodities and resource sectors, micro and macro relationships, or regional and national aggregations. Many economic philosophers and model builders will continue to be concerned the most with individual research activities. However, for some problems, a team approach will be necessary, just to complete all facets of model quantification. It also may be necessary for incorporating all of the relevant disciplines and subdisciplines.

In the early years of farm management and commodity marketing, a new study completed in one State resulted in a repetition in other States. While the local conditions were different, the methodology and general findings were often the same. For current-day problems, solutions are so urgently needed we perhaps require a greater degree than now exists of specialization and cooperation in the Nation's agricultural economics research effort. Thus, rather than a half-dozen econometrically based simulation models at six institutions, we would be better served by one or two models which develop and use other models and make them available.

Regional research projects of the State agricultural experiment stations generally do not provide the mechanism for such a pooling of resources because these projects have a short financing and planning horizon. Groups of universities do not have the flexibility in use of State funds to concentrate such efforts.

ERS perhaps is the single institution with a sufficient pool of professionals to accomplish this degree of specialization and concentration. This pool might also be used to aid specialized concentration on major problems and quantitative models in individual States. Such a goal could be accomplished if the ERS field staff were spread somewhat less thinly over many States and were instead concentrated more at centers of specialization. The Economic Research Service is large enough to have important influences on the quality, trends, and methods of agricultural economics research. Hopefully, ERS might evaluate the greater impact it could have on the agricultural economics profession. The opportunity to lead the profession is, I believe, greater than is being realized.

This note summarizes the ERS Bicentennial Lecture delivered by Earl O. Heady on December 1, 1976. Dr. Heady is Professor of Economics, Curtis Distinguished Professor of Agriculture, and Director of the Center for Agricultural and Economic Development at Iowa State University.

TESTING A THEORETICAL MODEL FOR WORLD TRADE SHARES

Alternative methods to link models developed through the forecasting and market studies projects being conducted in ERS by the Foreign Demand and Competition Division have been presented in a review paper by Schwartz (*13*).[1] Among models discussed are those that predict both the total volume of world trade and the flows of trade among regions. Schwartz downplayed the role of transportation costs as allocators of market shares, yet economic theory suggests these costs may be an important consideration. The focus here is on predicting the matrix of trade flows according to the hypothesis that the transport cost[2] of satisfying the regional demands is minimized. It will be shown that ERS regional trade models could benefit by incorporating this transportation cost hypothesis. In ERS, we have the theory, data, and computer routines, and this analysis suggests use of the hypothesis could improve our explanatory capability.

DATA REQUIREMENTS

The most essential data required are those for the transportation cost matrix. The amounts traded may be specified alternatively as (1) price-insensitive amounts imported or exported, (2) price-sensitive equations for net trade flows, or (3) individual regional demand and supply relations. Here, 1963-65 trade data for wheat, rice, and coarse grains in the form of method (1) were used.

The transportation cost matrix comes from (*10*, p. 128). Several changes were made to insure comparability between the rows of the transportation cost matrix and

[1] These included simple equilibrium models (*8*), optimizing spatial equilibrium models (*4, 12, 14, 15*), state transition dynamics (*1*), linkage by systems of demand equations (*2, 3, 5*), transportation models (*11*), and methods involving "desired distribution matrices" (*9*).

Note: Italicized numbers in parentheses refer to items in References at the end of this note.

[2] This hypothesis underlies the trade flows in spatial equilibrium models (for example, Takayama and Judge (*15*), Schmitz and Bawden (*12*)), which simultaneously determine the regional totals and the matrix of trade flows. The Abel-Waugh state transition dynamics approach to trade flows (*1*) makes no *a priori* assumption regarding the origin of the base period trade flow matrix. The Loubal-McBride "desired distribution matrix" approach (*9*) needs some external (or policy) specification of the "desired" matrix of trade flows. The transportation cost hypothesis could be used to form either this matrix or the initial matrix in the Abel-Waugh methodology.

those of the trade flow matrix.[3] An economic relationship to update the transportation costs would probably include port-to-port mileage, fuel prices, the size of the world tanker fleet, and a measure of congestion—in both the importing and exporting facilities. If the structural model is not feasible, a minimal effort would be to index the table to the costs along one or two major shipping routes; any cost changes would determine the current cost estimates. Such an approach is very similar to that of Takayama and Hashimoto (*14*).

ADEQUACY OF PREDICTED TRADE FLOWS

The predicted pattern of trade will be found through solution of a linear program. The number of basis activities (nonzero trade flows) is much less than the total number of activities (potential trade flows); most of the predicted trade flows are zero. If the cost-minimizing assumption adequately describes the trade flow, the major observed flows will correspond to the predicted nonzero flows and the observed minor flows will correspond to the nonbasic (zero) flows. Thus, the correlation between the predicted and actual flows will be high.

For the analysis presented here, a description which explains less than 50 percent of the variation ($r < 0.707$) in actual trade flows was considered inadequate. Table 1 contains the results of a statistical test of this hypothesis, based on Fisher's transformation of the correlation coefficient to an asymptotically normal random variable.[4] The conclusions of the statistical test are that the transport cost-minimizing hypothesis adequately explains the market shares for rice and coarse grains, but not wheat.

Country-by-country comparisons of the market share distributions appear in table 2. The first column is the correlation of a region's predicted exports by destination with its actual distribution of exports. The second column is the correlation of the predicted imports by source with the actual distribution of imports into that region. The third column is the net trade position of that region for the commodity; negative numbers imply that imports exceed exports. The prediction errors for each region are typically larger than the errors in predicting the overall world trade distribution.

The rice trade among the less developed countries (LDC's) and the feed grain trade among the developed countries are particularly well explained. For rice, both import and export correlations in the regions from Latin America to the Far East are all 0.5 or better. For coarse grains, the same is true for the correlations in the direction of the trade flows in the regions listed from the United States to Australia (excepting other Western Europe). For wheat, distributions seem better explained for imports than for exports. Argentina is the only major wheat exporter whose shipments are well explained by the transportation hypothesis. South Asia, the USSR, and Africa are the only wheat importers whose supplies are not explained by the transportation cost hypothesis.

The predicted distribution of U.S. exports of both wheat and rice differed from their actual pattern. In each case, actual shipments were more to South Asia and less to Eastern Europe and the USSR. Both these aberrations reflect forces other than that of the market impacting on the system. The politics of trade with the Communist bloc[5] and the forces motivating food aid to

[3] An example of such a change is that the Latin American rate is the simple average of the rates to Central America, Eastern South America (Rio), and Western South America (Callao). Further, the rate to and from the regions of Australia and New Zealand (and sometimes the Union of South Africa) was taken to be the rate for Australia and New Zealand (Melbourne). The Far East and Oceania region was taken to have the transportation rates for East Asia and Pacific (Singapore). For other East Asia, the rates to and from Japan (Yokohama) were used.

[4] If r and ρ are the sample and population correlations, consider the transformations below:

$$z = \tfrac{1}{2} \ln (1 + r) / (1 - r) \text{ and } \zeta = \tfrac{1}{2} \ln (1 + \rho) / (1 - \rho)$$

It can be shown that z is distributed asymptotically Normal with mean ζ and variance $(n - 3)^{-1}$. Although there are 400 possible flows in a 20 x 20 region world, the constraints imposed by the regional totals reduce the freely assignable flows to 361. In analysis presented here, the sample size (361) is large enough to neglect the small sample biases. For more detail, see Yule and Kendall (*17*, p. 451), Hays and Winkler (*7*, p. 610), or a number of other statistics texts.

[5] See Hadwiger (*6*, p. 78).

Table 1.—Statistical test of trade flow correlation coefficients

Commodity	Correlation	Statistical test[1]			
		z^2	Decision	Error probability	
				Type I error[3]	Type II error[4]
Rice	0.8922	10.35	Accept H_O	N/A	0.0
Coarse grains	.7890	3.53	Accept H_O	N/A	.00025
Wheat	.4054	-8.48	Reject H_O	[5]0.0	N/A

[1] Null hypothesis: population correlation is greater than or equal to 0.707, versus the one-sided alternative that the correlation is less than 0.707. [2] Defined in footnote 4 in text. [3] Reject a true null hypothesis. [4] Accept null hypothesis when the alternative is true. [5] Probability less than 10^{-6}. Note: N/A means not applicable.

Table 2.—Net trade and market share correlations, by region and commodity

Region	Rice			Coarse grains			Wheat		
	Correlations		Net trade	Correlations		Net trade	Correlations		Net trade
	Exports	Imports		Exports	Imports		Exports	Imports	
			Thous. metric tons			*Thous. metric tons*			*Thous. metric tons*
United States	0.15	-0.09	1,327	0.92	-0.07	15,966	0.24	-0.05	20,436
Canada	.95	.97	-35	.69	-.05	1,016	.45	1.00	13,221
Japan	1.00	.38	-534	1.00	.84	-4,658	.24	.77	-3,452
European Community	.51	.56	-144	.80	.91	-10,474	.23	.23	927
United Kingdom	-.06	.70	-79	-.08	.47	-3,961	-.08	.92	-4,254
Other Western Europe	.01	.14	-93	.38	.03	-4,268	-.08	.48	-1,578
Australia and New Zealand	[1] -.00	.53	-27	.50	1.00	2,101	.05	.82	5,901
Eastern Europe	1.00	-.03	-318	.47	.17	-1,707	.91	.51	-6,191
Soviet Union	-.08	.48	-243	-.06	1.00	2,044	-.08	.14	-3,064
Communist Asia	.28	.27	747	-.05	-.12	-216	-.05	.46	-5,274
Argentina	-.10	1.00	10	.05	-.05	3,919	.72	1.00	3,967
Other Latin America	.93	.64	-242	.03	.04	107	.90	.81	-5,302
North Africa	.65	.47	215	.02	[1] -.00	8	.11	.95	-2,898
West Africa	1.00	.68	-369	[2] .00	-.02	-13	-.07	-.09	-469
East Africa	.73	.99	-178	.42	.32	-17	.69	[1] -.00	-231
West Asia	.89	.65	-295	.69	.29	-214	.88	.95	-1,797
South Asia	.46	.91	-1,156	-.05	-.06	-64	1.00	-.01	-7,629
Southeast Asia	.96	.68	3,656	.45	-.05	948	-.05	.16	-211
Other East Asia	.99	.88	-717	1.00	1.00	-350	.20	.98	-1,558
Far East and Oceania	.96	.99	-1,525	.69	1.00	-167	1.00	.89	-544
World total	.8922		7,153	.7890		34,739	.4054		52,929

[1] -.00 indicates correlation whose value lies between 0.0 and -.005. [2] .00 indicates correlation whose value lies between 0.0 and .005.

the Indian subcontinent[6] disrupt the (more nearly) free market equilibrium pattern of trade which minimizes transport costs. The shift to a more "market-oriented" agriculture in the seventies has resulted in more trade with the Soviets and less with India—much as the model presented here would predict.

To capture the effects of these nonmarket forces, the following adjustments to the programmed solution were made. Diverting the entire predicted U.S. trade flow to Eastern Europe (318,000 metric tons) into South Asia would increase the correlation for the U.S. export distribution of rice from 0.15 to 0.70.[7] Similarly, diverting the 2.505 million metric tons predicted as U.S. exports of wheat from the USSR to South Asia would increase the correlation for the U.S. wheat export distribution from 0.24 to 0.55.[8]

CONCLUSIONS

Minimizing the transportation costs is a good analytical method to use to allocate regional market shares. It explained a significant portion of the market shares of rice and coarse grains. But food aid and other policy considerations seem to supplement the cost-minimizing hypothesis in the market for wheat. The transportation model allows for changing market shares in response to differing export supplies and import demands. Moreover, it remains valid even if a proportional increase of all transportation costs occurs.

Transportation cost minimization is not inconsistent with any of the share mechanisms being considered by FDCD, and economic theory says that such minimization should underlie any allocating mechanism. Algorithms for solution are available and inexpensive, and the basic transportation cost matrix for one point in time is also available. If FDCD's market studies projects will be concerned with who exports to whom, any allocating device should start with this mechanism. To bring the model on-line, only the transportation cost matrix needs

[6] See (*16*, pp. 150-151 and 170-171). Refers to U.S. agricultural exports under P. L. 480.

[7] This change required adjustment of the export flows of Southeast Asia, raising the overall correlation from 0.8922 to 0.9127.

[8] In this case, predicted Australian exports to South Asia would be diverted to Communist Asia, and Canadian exports to Communist Asia would be diverted to the Soviet Union. This adjustment increased the overall correlation of wheat market shares from 0.4054 to 0.6329, which differs from 0.707 by a Normal deviate of -2.10 (type I error probability is 0.0179).

to be updated, because other efforts of FDCD involve estimating total imports and exports by region.

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WHEAT FARMERS' DEMAND FOR COMMODITY LOANS, 1950-75

By law, the Commodity Credit Corporation (CCC) must make wheat loans to farmers using the crop as collateral, or it must purchase wheat from farmers at the announced loan rate. Farmers can voluntarily place any amount of their crop under loan at this rate. To forecast farmers' use of this wheat loan program, the Agricultural Stabilization and Conservation Service (ASCS) needs a simple model. ASCS analysts use such forecasts to estimate CCC capital outlays and to plan work loads in State and county ASCS offices. We present here results of an analysis made to improve such loan forecasting by identifying relevant variables.

We expect that the demand curve for wheat under loan is downward sloping. The supply is considered perfectly elastic, because at any given ratio of the market price to the support price of wheat, any quantity of wheat not exceeding total production in a given year can be used as collateral for loans. Therefore, a simultaneous equation model for supply and demand was not needed. A single equation with four independent variables was found to explain most of the annual variation in loans. The price variable is the ratio of wheat's market price to its support price (loan rate). We hypothesized that variables other than this ratio influence the quantity of wheat placed under loan.

The following equation was used:

$$WLV = B_0 (WC)^{B1} (WCOS)^{B2} (WP)^{B3} (WFSH)^{B4} (WMSPR)^{B5} (WCPR)^{B6} (WSRPR)^{B7} (IR)^{B8}$$

Where

WLV	=	Volume of wheat under the loan program
WC	=	Domestic consumption of wheat
WCOS	=	Carryover stocks of wheat in the preceding year
WP	=	Production of wheat
WFSH	=	Total foreign shipments of wheat
WMSPR	=	Ratio of market price to support price of wheat
WCPR	=	Ratio of the price of wheat to the price of corn
WSRPR	=	Ratio of the price of wheat to the price of sorghum
IR	=	Interest rate charged by production credit associations

The model estimates a positive loan volume of wheat unless one of the independent variables takes a value equal to zero, which is most unlikely. The model is easily estimable because it becomes linear when logarithms are taken. Elasticities of loan volume of wheat are directly provided. The model also provides zero volume of wheat under loan, when the price support program is withdrawn, if the estimated coefficient of the ratio of market price to the support price of wheat (B5) is negative, as logically expected.

Data for 1950-75 were taken from *Agricultural Statistics*, published by the U.S. Department of Agriculture (table 1). The loan volume fluctuated highly, recording

Table 1.--Time series data on variables included in analysis of wheat loan volume under price support program, 1950-75

Year	WLV	WC	WCOS	WP	WFSH	WMSPR	WCPR	WSRPR	IR
	Million bushels								
1950	197.0	680.0	307.3	1019.4	365.9	1.0050	1.3158	1.9048	6.01
1951	213.0	689.8	424.7	988.2	475.0	.9679	1.2711	1.5985	6.08
1952	460.0	688.6	399.9	1306.4	317.5	.9500	1.3750	1.3228	6.33
1953	553.0	661.0	256.0	1173.1	216.7	.9231	1.3784	1.5455	6.35
1954	430.0	633.9	605.5	983.9	274.0	.9464	1.4825	1.6825	6.36
1955	318.0	611.4	933.5	935.1	346.0	.9519	1.4667	2.0204	5.92
1956	252.0	603.7	1036.2	1005.4	549.1	.9850	1.5271	1.7130	6.20
1957	256.0	588.7	1033.5	955.7	402.3	.9650	1.7387	1.9897	6.66
1958	609.0	591.7	908.8	1457.4	442.8	.9615	1.5625	1.7500	6.72
1959	317.0	608.6	881.4	1117.7	509.8	.9724	1.6762	2.0465	6.50
1960	424.0	596.9	1295.1	1354.7	661.5	.9775	1.7400	2.0714	7.25
1961	271.0	603.4	1313.4	1232.4	719.4	1.0223	1.6636	1.8119	6.61
1962	300.0	608.0	1411.3	1092.0	643.8	1.0200	1.8214	2.0000	6.36
1963	172.0	580.3	1322.0	1146.8	856.1	.9113	1.6667	1.8878	6.30
1964	206.0	588.5	1195.2	1283.4	752.0	.7697	1.1709	1.3048	6.47
1965	173.0	643.6	901.4	1315.6	867.4	.7849	1.1638	1.3500	6.58
1966	133.0	731.2	817.3	1311.7	744.3	.8579	1.3145	1.5825	6.87
1967	282.0	673.1	535.2	1522.4	761.1	.7514	1.3495	1.4040	7.29
1968	453.0	633.3	425.0	1576.3	544.2	.6776	1.1481	1.3053	7.34
1969	408.0	735.4	539.4	1460.2	606.1	.6443	1.0783	1.1589	7.34
1970	254.0	771.6	818.6	1370.2	737.5	.6650	1.0000	1.1667	8.98
1971	438.0	768.6	884.7	1639.5	632.5	.7486	1.2407	1.2762	7.28
1972	143.0	854.7	731.5	1544.9	1190.3	1.0233	1.1210	1.2847	7.02
1973	60.0	784.6	863.1	1705.2	1148.5	2.7055	1.5490	1.8453	8.09
1974	36.0	751.3	438.4	1796.2	1040.0	1.9951	1.3498	1.4712	9.43
1975	50.0	751.3	247.4	2133.8	1168.0	1.7171	1.4309	1.4915	8.91

Source is *Agricultural Statistics*, 1950-75.

its highest level of 609 million bushels in 1958 and its lowest level of 36 million bushels in 1974. The volume of wheat under loan has been substantially lower in the last few years mainly because the wheat market price has been much higher than the wheat loan rate, and foreign shipments of wheat, substantially higher than earlier.

Multicollinearity does not appear to be a serious problem (table 2). The correlation between the logarithms of any two variables is very low, except in two cases: correlation between wheat production and interest rate charged by production credit associations is 0.815; between the wheat-sorghum price ratio and the wheat-corn price ratio, 0.90. One variable from each pair could be deleted from the forecasting equation.

The regression coefficients, T values, and R^2 values appear in table 3. Variables are listed in the order in which they entered a stepwise regression program. These four variables are statistically significant at the 1-percent level: carryover stocks (+), wheat production (+), foreign shipments (-), and ratio of wheat to loan price (-). The signs are as expected.

Coefficients for domestic consumption, interest rate charged by production credit associations, wheat-corn price ratio, and wheat-sorghum price ratio are not statistically significantly different from zero, even at the 10-percent level of significance.

The regression equation with all the included independent variables explained about 92 percent of the year-to-year variation in the volume of wheat under loan during 1950-75.

The chart compares the actual volume of wheat under loan for the period studied with estimates from equation number 8. The difference between the actual and the estimated volume of wheat in the last few years appears to be very narrow. Thus, the model appears to be fairly reliable for projecting the volume of wheat under loan.

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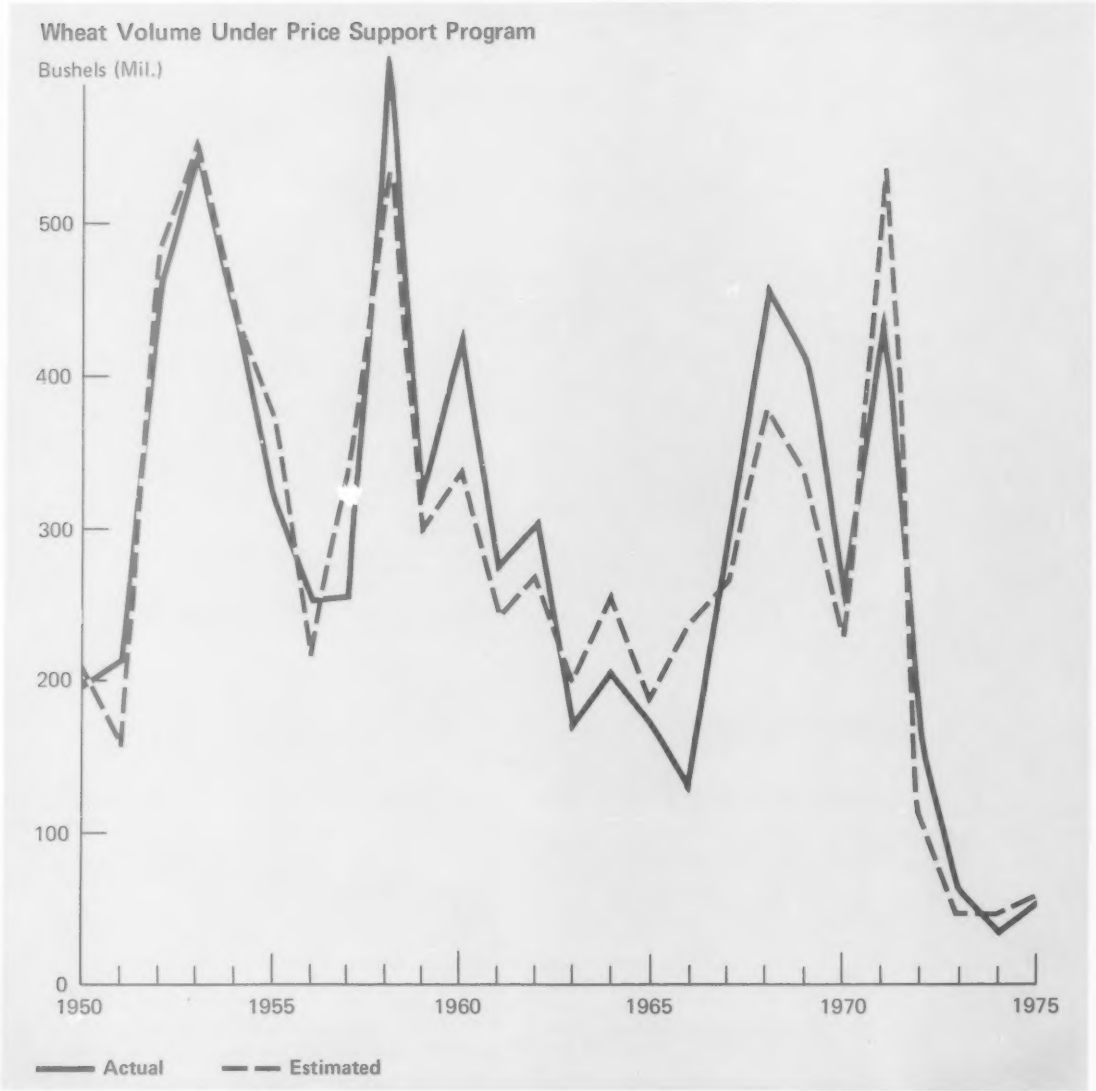
Table 2.—Correlations among variables in wheat loan volume analysis*

Variable	WCL	WCOSL	WPL	WFSHL	WMSPRL	WCPRL	WSRPRL	IRL	WLVL
WCL	1.000								
WCOSL	-0.045	1.000							
WPL	0.602	-0.272	1.000						
WFSHL	0.428	0.254	0.661	1.000					
WMSPRL	0.273	-0.147	0.327	0.353	1.000				
WCPRL	-0.588	0.385	-0.333	-0.159	0.398	1.000			
WSRPRL	-0.572	0.353	-0.521	-0.230	0.367	0.900	1.000		
IRL	0.605	-0.220	0.815	0.613	0.357	-0.321	-0.438	1.000	
WLVL	-0.462	0.146	-0.443	-0.709	-0.734	0.045	0.010	-0.535	1.000

*The final "L" in an acronym indicates a logarithm to the base 10.

Table 3.—Regression coefficients, t values, and $\bar{R}^2$ in wheat volume under loan regression analysis

Equation	BO constant	B5 WMSPR	B4 WFSH	B6 WCPR	B3 WP	B2 WCOS	B8 IR	B1 WC	B7 WSRPR	$\bar{R}^2$
1.	2.3532	-1.63217								
		(-5.3013)								0.5394
2.	4.6224	-1.2296	-0.81635							
		(-5.1845)	(-4.8151)							0.7706
3.	4.0889	-1.51589	-0.681633	1.09434						
		(-6.08255)	(-4.11835)	(2.33736)						0.8163
4.	1.36134	-1.73393	-0.937791	1.63166	1.07932					
		(-7.4169)	(-5.3985)	(3.5662)	(2.71197)					0.8639
5.	-0.27251	-1.33940	-1.39528	0.769344	1.61355	0.380483				
		(-5.7036)	(-6.6999)	(1.61594)	(4.27489)	(3.08983)				0.9079
6.	-0.632593	-1.27141	-1.37702	0.642234	1.94682	0.488940	-0.871521			
		(-5.3551)	(-6.69728)	(1.33958)	(4.28079)	(3.18945)	(-1.27213)			0.9151
7.	-3.01399	-1.39805	-1.39608	1.02813	1.91418	0.508995	-0.962817	0.884925		
		(-5.39356)	(-6.83094)	(1.77475)	(4.23987)	(3.32972)	(-1.40906)	(1.16376)		0.9211
8.	-3.29384	-1.42245	-1.40649	0.858393	1.99259	0.512306	-0.961062	0.897098	0.216285	
		(-5.0904)	(-5.60526)	(1.02148)	(3.70009)	(3.25592)	(-1.37009)	(1.14758)	(0.285879)	0.9214



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